

SPGR Sub-Project Completion Report
On

**Coordinated Sub-project on Characterization of Important Plant
Genetic Resources- BINA Component**

Duration: December 2011 to June 2014

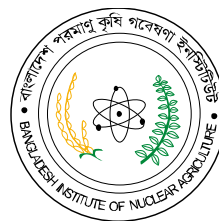
Executing Organization

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Submitted to



PIU-BARC, NATP: Phase-1
BARC Complex
Farmgate, Dhaka-1215



June 2014

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Executive Summary:

Identification and utilization of diverse germplasm is the vital issue in plant breeding. Molecular markers have been proved to be valuable tools in the characterization and evaluation of genetic diversity within and between species and populations. This Project was undertaken for protection of plant genetic resources through identification and utilization of diverse germplasm using morpho-molecular characterization of crop varieties and germplasm of Bangladesh Institute of Nuclear Agriculture and selected Geographical Indication (GI) crops (Sonamoog, Mashkolai and Local til). Morpho-physiological data were collected from the field during the growing stage of the tested crop varieties/germplasm according to descriptors of International Plant Genetic Resources Institute (IPGRI). Morphological characterization was done in 57 varieties and 173 germplasm of 12 crops. Molecular characterization was done in 31 varieties out of 57 and 102 germplasm out of 173 using SSR and/ RAPD markers. Morpho-molecular characterization of 3 GI crops ('kali kolai' of blackgram, 'sonamoog' of mungbean and 'local til' of sesame) was also done.

The GI sonamoog possess attractive seed coat colour having light green leaf; local til usually shattered and low yielding; and plant height varies differently in kali kolai. There were wide variation (green, purple, greenish purple) in colour of leaf blade joint, petiole and basal petioles among the AVRDC genotypes and varieties of mungbean genotypes. Generally, chickpea varieties/genotypes are light brown to dark brown but mutant variety Binasola-5 possesses distinct green seed and seed coat colour. The highest pod number and the smallest seed weight were present in Hyprosola. Stipule is modified in mutant variety Atompat-38 which distinguishes other jute varieties/germplasm. Soybean varieties exhibit different seed colour. Glabrous to very sparse are observed in mustard varieties. Non-branching or unicum habitat is found in Binatil-1. Different fruit shapes are found in tomato varieties and germplasm. Rice varieties and germplasm are distinctly different with respect to grain colour, grain size-shape, length-breadth etc. Considering the genetic distance values the result indicated that some genotypes of different crops are genetically different from each other and some are tend to be similar. These diversified germplasm could be conserved as a genetic resource for future plant breeding programme.

Main report content:

- 1. Sub-Project title : Coordinated Sub-project on Characterization of Important Plant Genetic Resources- BINA Component**
- 2. Principal Investigator/Co-principal investigator :**
Principal Investigator: Dr. Shamsun Nahar Begum, Senior Scientific Officer
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- 4. Duration of the sub-project:** December 2011; End: June 2014
- 5. Date of approval** (by the Executive Council/signing of LoA) : 5 December, 2011
- 6. Total approved Budget** (Taka): 18,91,700.00 (Eighteen lakh ninety one thousand seven hundred only)

Total fund received (Tk.)	Total fund spent (Tk.)	Unspent/balance fund (Tk.)
18,91,700.00	18,91,700.00	00.00

Justification of undertaking the sub-project:

Characterization and documentation of diverse germplasm is the vital work for plant breeder. Thorough knowledge of the genetic diversity of the crop is necessary for parental selection that maximizes genetic improvement. More accurate and complete descriptions of genotypes and patterns of genetic diversity could help determine future breeding strategies and facilitate introgression of diverse germplasm into the current commercial variety genetic base.

Characterization and quantification of genetic diversity has long been a major goal in evolutionary biology. Information on the genetic diversity within and among closely related crop varieties is essential for a rational use of genetic resources. The analysis of genetic variation both within and among elite breeding materials is of fundamental interest to plant breeders. It contributes to monitoring germplasm and can also be used to predict potential genetic gains. Diversity based on phenological and morphological characters usually varies with environments and evaluation of these traits requires growing the plants to full maturity prior to identification. The International Board for Plant Genetic Resources (IBPGR) promotes a minimum set of morphological characters thought satisfactory for the custodial management of crop germplasm collections. The purpose of such conserved germplasm is as a genetic resource for future plant breeding programmes. Because future plant breeding requirements are not always known, the curator's strategy in maintaining an adequate germplasm resource is to conserve as wide a range of genetic diversity as possible. A geographical indication (GI) crop is referred to that crop which is grown in particular environment or habitat where it originates, sustain and perform well. GI crops are rare, valuable and bear special characters which are very much identical. It has special value, colour and taste which attracts consumer and even more expensive than other modern or high yielding varieties. Therefore, protection and characterization of GI crops is urgent need from genetic erosion or extinct. Protein or isozyme marker studies are also influenced by environment and reveal low polymorphism. Molecular markers have been proved to be valuable tools in the characterization and evaluation of genetic diversity within and between species and populations.

Now, the rapid development of biotechnology allows easy analysis of a large number of loci distributed throughout the genome of plants. The use of advanced molecular technologies is one possible approach to understand their diversity. Several molecular markers viz. RFLP (Sun *et al.*, 2001), RAPD (Ravi *et al.*, 2003), SSRs (Eizenga *et al.*, 2009; AFLP (Bao *et al.*, 2006) and SNPs (Shirasawa *et al.*, 2006) are presently available to assess the variability and diversity at molecular level. Information regarding genetic variability at molecular level could be used to help, identify and develop genetically unique germplasm that compliments existing cultivars. Recently, microsatellites or simple-sequence repeats (SSRs) have become an ideal marker system of choice owing to their abundance in the genomes, hypervariability, co-dominance and high reproducibility (Gao *et al.*, 2006).

Therefore, morpho-molecular characterization of plant genetic resources is urgent need for documentation and future breeding.

7. Sub-project objectives:

- 1) Morphological characterization of different varieties, germplasm and GI crops
- 2) Characterization of different varieties, germplasm and GI crops at molecular level using molecular markers (SSR, RAPD, STS, SNP and other markers)
- 3) Documentation of characterized different varieties, germplasm and GI crops

8. Methodology followed in conducting research/investigation:

A total of three GI (one each of Sesame, Blackgram and Mungbean crop), 57 developed improved and high yielding varieties and 173 germplasm of 12 BINA Mandated crops were used for this study. The list of i) number of crops, varieties and germplasm were to be characterized as per project proposal, ii) name of crops and number of GI crops, variety, cultivar, genotypes as per revised project proposal or based on the decision of the meeting/workshop target and iii) achievement (in tabular form) of the project is presented below:

(1) Target of characterization as per project proposal

Name of crops	Target of characterization (as per PP)							
	GI		Cultivar		Variety		Germplasm	
	Mor	Mol	Mor	Mol	Mor	Mol	Mor	Mol
Rice	-	-	-	-	7	7	60	60
Mustard	-	-	-	-	8	8	15	15
Sesame	-	-	-	-	2	2	6	6
Soybean	-	-	-	-	2	2	22	22
Groundnut	-	-	-	-	6	6	8	8
Mungbean	1	1	-	-	8	8	12	12
Chickpea	-	-	-	-	6	6	10	10
Lentil	-	-	-	-	6	6	20	20
Blackgram	1	1	-	-	1	1	-	-
Grasspea	-	-	-	-	1	1	-	-
Tomato	-	-	-	-	7	7	10	10
Jute	-	-	-	-	3	3	5	5
Total	2	2	-	-	57	57	168	168

(2) Target of characterization (Revised):

Name of crops	Target of characterization ((Revised))							
	GI		Cultivar		Variety		Germplasm	
	Mor	Mol	Mor	Mol	Mor	Mol	Mor	Mol
Rice	-	-	-	-	8	8	60	60
Mustard	-	-	-	-	8	8	9	9
Sesame	1	1	-	-	2	2	6	6
Soybean	-	-	-	-	2	2	12	12
Groundnut	-	-	-	-	6	6	8	8
Mungbean	1	1	-	-	7	7	27	27
Chickpea	-	-	-	-	6	6	10	10
Lentil	-	-	-	-	6	6	22	22
Blackgram	1	1	-	-	1	1	-	-
Grasspea	-	-	-	-	1	1	-	-
Tomato	-	-	-	-	7	7	14	14
Jute	-	-	-	-	3	3	5	5
Total	3	3	-	-	57	57	173	173

(3) Achievement:

Name of crops	Characterization done (final output)							
	GI		Cultivar		Variety		Germplasm	
	Mor	Mol	Mor	Mol	Mor	Mol	Mor	Mol
Rice		-	-	-	8	8	60	50
Mustard		-	-	-	8	6	9	4
Sesame		1	1	-	2	1	6	6
Soybean		-	-	-	2	1	12	5
Groundnut		-	-	-	6	4	8	-
Mungbean		1	1	-	7	1	27	4
Chickpea		-	-	-	6	6	10	1
Lentil		-	-	-	6	-	22	22
Blackgram		1	1	-	1	-	-	-
Grasspea		-	-	-	1	1	-	-
Tomato		-	-	-	7	4	14	8
Jute		-	-	-	3	5	5	2
Total		3	3	-	57	37	173	102

Total number of crops characterized: 12

Total number of morphological characterization: 233

Total number of molecular characterization: 136

Morphological Characterization:

For identification of the distinct morphological characters of the GI/variety/germplasm, seeds of different crop varieties have been collected from the original source and plants were raised as per season both in the field and in the Labs. In this study, morpho-physiological data were collected from the field during the different growth stages of the tested varieties/germplasm/GI crops according to descriptors of International Board for Plant Genetic Resources (IBPGR).

Genotypic Characterization:

Characterization of the GI/variety/germplasm of different crops at their molecular level is very important. Use of inbred for long in the private and public sector through seed increases over years may absorb variations of different nature and that may not be very much clear at the agronomic or even morphological levels so the identification of the polymorphism at DNA level is required. High level of polymorphism allows a rapid and efficient identification of different genotypes.

Collection of leaf sample

Samples were collected from young, vigorous leaves from 25 day old seedlings to extract genomic DNA. At first, the healthy portion of the youngest leaves of different crops were cut apart with sterilized scissors and washed in ethanol (70%) and distilled water (Fig.2). The collected leaf samples were then kept in polythene bags with marking. The bags were placed in an ice box to carry it in the laboratory for avoiding any damage of the leaf tissues. Tag was maintained for each sample. After that the polythene bags were wrapped by aluminum foil and stored at -80°C freezer.

Genomic DNA extraction

DNA was extracted from the leaves of each genotype using the modified Cetyl Trimethyl Ammonium Bromide (CTAB) mini-prep method (Zheng *et al.*, 1995). The quality of the isolated DNA in the protocol was sufficient for PCR. The following steps were followed in PCR-based DNA marker analysis.

The leaf samples were ground with pestle and mortar to collect DNA. Strict hygiene was maintained during the DNA extraction by autoclaving all glassware, micropipette tips, PCR tubes, distilled water, reagents and buffer solutions. The following steps were followed for DNA extraction:

- The leaf samples were cut into 2-3 cm pieces and the sample was ground
- 670 µl extraction buffer and 50 µl 20% SDS were added
- Then the mixture was Vortexed for 20 second and incubated for 10 minutes at 65°C in the hot water bath
- 100 µl 5M NaCl was added and inverted gently to suspend the samples evenly
- Then 100 µl CTAB was added and mixed well
- Again, the mixture was vortexed for 20 second and incubated for 10 minutes at 65°C in the hot water bath
- 900 µl chloroform (chloroform: isoamylalcohol = 24:1, v/v) was added and mixed well
- The samples were spun down at 12000 rpm for 15 minutes
- Then the supernatant was transferred into a new eppendorf tube and 600 µl ice-cold isopropanol was added to the supernatant and shakened well
- The mixture was again spun down at 12000 rpm for 15 minutes by centrifuge
- The Supernatant was discarded and the pellet was washed with 200 µl 70% ethanol
- At last the samples was spun down again at 12000 rpm for 5 minutes, the ethanol was removed and the pellets were allowed for air-drying for 1 hour
- The pellet was then suspended in 30µl 1X TE buffer
- Finally, the DNA samples were stored at - 20°C

Confirmation of DNA

Isolated genomic DNA contains a large amount of RNA and pigments, which cause over estimation of DNA concentration. Therefore, the DNA samples were evaluated qualitatively using agarose gel electrophoresis.

DNA confirmation using gel electrophoresis

Preparation of 0.8% Agarose gel (250 ml)

- 250 ml 0.5X TBE (electrophoresis buffer) was taken in a flask and 2.0 g of agarose was added to it
- The mixture was then kept in microoven and cooked for 5 minutes to dissolve it
- The gel was kept in room temperature for 10-15 min to cool down at tolerable level
- The gel was then poured into gel mold carefully
- Meanwhile combs were placed on the gel
- Within 30 minutes the gel was solidified
- The gel was submerged into 0.5X TBE buffer in the gel tank
- The combs were removed from the gel
- The gel was then ready for loading the DNA samples

Procedure

- Loading dye (3µl) was placed on a piece of parafilm paper using micropipette.
- 3 µl extracted DNA sample was added to it and mixed well and then the mixture was loaded in the slot of the gel.
- The known DNA marker (λ DNA) was loaded in the first 3 lanes of the gel.
- The gel tank was submerged with 0.5X TBE and the electrophoresis apparatus were connected to the power supply unit.
- After switching on the DNA was migrated from negative to positive electrode.
- Two colors (dye) appeared after few minutes.
- The separation was monitored by the migration of the dye in the gel.
- When the first dye (bromophenol blue) had reached two-third of the gel length then the power supply was cut off.
- Electrophoresis was carried out for 1-1.30 hr.

Documentation of the DNA samples

- After electrophoresis, the gel was taken out carefully from the gel chamber and transferred in a prepared ethidium bromide solution for staining.
- Staining was done for 20 minutes and then placed on the UV transilluminator in the dark chamber of the Image Documentation System.
- The UV light of the system was switched on. The image was visualized on the monitor and the photograph was saved in the Gel Doc computer.

DNA quantification

Before PCR amplification it is important to know the concentration of genomic DNA because different DNA extraction methods produced DNA of different purity. It is necessary to optimize the amount of DNA to achieve reproducibility and strong signal in PCR assay. Excessive genomic DNA may result smears or lack of clearly defined bands in the gel. On the other hand, too little DNA will give non-reproducible patterns (Williams *et al.*, 1993). For quantification of DNA concentration λ (Lambda) DNA method was applied.

Lambda (λ) DNA (concentration marker): λ DNA was used for quantification of DNA concentration as 0.5 µl, 1.0 µl, and 2.0 µl. It is consequential that 0.5 µl λ DNA contains 25 ng/µl DNA. Five microliter 2X loading dye was mixed with the 3µl DNA sample of each germplasms. Then 8µl DNA sample was loaded to the 0.8% agarose gel on the gel tank. λ DNA was loaded in first 3 wells as known DNA concentration marker. The electrophoresis machine was run for 2 hr at 100 volts. Two colours (dye) were taking apart after few minutes by the migration of the dye in the gel. Then the first dye (brornophenol blue) had reached two-third of the gel length, then the power supply was switched off and the gel was stained with ethidium bromide solution. After staining, the gel was placed in gel doc and DNA bands were visualized by UV light. Care should be taken during carry out ethidium bromide and UV light. Some DNA bands of the germplasms were highly concentrated, some bands were found hazy and some showed smears.

Preparation of working solution of DNA samples

Before running the samples in PCR machine/ program the DNA concentrations were adjusted to 25 ng/ µl using the following formula:

$$S_1 \times V_1 = S_2 \times V_2$$

Where,

S₁: Initial strength (ng/µl)

V₁: Initial volume (µl)

S₂: Final strength (ng/µl)

V₂: Final volume (µl)

Amplification of RAPD markers by polymerase chain reaction (PCR)

To perform the amplification of RAPD, a single oligonucleotide of arbitrary DNA sequence was mixed with genomic DNA in the presence of a thermostable DNA polymerase and suitable buffer then subjected to temperature cycling conditions typical to the polymerase chain reaction (PCR).

Preparation of reaction mixture for PCR

The following components were used to prepare PCR cocktail (Table 1). The total volume of PCR cocktail was eight μl per sample. PCR reactions were performed on each DNA sample in a 10 μl reaction mix containing the following reagents:

Table 1. Reagent used in PCR reaction

Reagents	Amount (per reaction)
Ampli <i>Taq</i> polymerase buffer (10X)	1 μl
Primer (10 μM)	2.0 μl
dNTPs (250 μM)	1 μl
Ampli <i>Taq</i> DNA polymerase	0.2 μl
Sterile deionized water	3.8 μl
Sub-total =	8 μl
Genomic DNA (25ng/ μl)	2 μl
Total =	10 μl

Two micro liters genomic DNA of each sample was taken in 0.2ml PCR tubes. Then 8 μl of PCR cocktail were add to the tubes and mixed gently. The tubes were sealed and placed in a thermocycler (Biometra, Germany).

Thermal profile

The PCR tubes were set on the wells of the thermocycler. Then the machine was run according to the following setup

- Initial denaturation at 94°C for 3 min
- Denaturation at 94°C for 1 min
- Annealing at 34°C for 1 min
- Elongation or extension at 72°C for 2 min
- Step 2 to step 4 reaped 40 more cycles
- Final extension at 72°C for 7 min
- Completion of cycling program, reactions were held at 4°C.

Agarose gel electrophoresis of the amplified product

Agarose gel (1.5%) was prepared and poured into platform carefully when the gel solution cooled at 55°C. Let the gel polymerize for at least 30 minutes before removing the combs. After removing the casters, gel with platform was placed at the tank and poured 0.5X TBE buffer into the tank to submerge the gel. Then the combs were removed cautiously that gel slots were not injured.

Then the PCR products from each sample were confirmed by running 1.5% agarose gel. The PCR products were mixed with 3 μl of 2X gel loading dye. 13 μl of the mixture was loaded slowly per well on the gel in the gel tank and allowed them to sink in the bottom of the wells. The molecular weight marker (20 bp DNA ladder) was loaded at the first well on the gel. The tank was covered and all connections were checked. Electrophoresis machine run for 1.5-2.0 hr. The separation process was monitored by the migration of the dyes in the loading buffer. When the bromophenol blue dye had reached about three-fourth of the gel length, the electrophoresis was switched off.

Ethidium bromide staining

After completion of electrophoresis the gel was soaked in ethidium bromide (10 mg/ml) solution for 20-25 minutes.

Documentation of the DNA samples

After staining, the gel was taken out carefully from the staining tray and placed on high performance ultraviolet light box (UV transilluminator) of gel doc for checking the DNA bands. The DNA was observed as band and saved the records.

RAPD data analysis and dendrogram construction

Since RAPD markers are dominant, we assumed that each band represented the phenotype at a single allelic locus (Williams *et al.*, 1993). Following electrophoresis, the sizes of amplification products were estimated by comparing the migration of each amplified fragment with that of a known size fragments of molecular weight markers: 20 bp DNA ladder and PUC ladder. All distinct bands or fragments (RAPD markers) were thereby given identification numbers according to their position on the gel and scored visually on the basis of their presence (1) or absence (0), separately for each individual and each primer.

The scores obtained using all primers in the RAPD analysis were then combined to create a single data matrix. This was used for estimating polymorphic loci, Nei's (1973) gene diversity, genetic distance (GD) and constructing a UPGMA (Unweighted Pair Group Method of Arithmetic Means) dendrogram among the populations using computer program POPGENE (Version 1.31) (Yeh *et al.*, 1999).

Amplification of SSR markers by Polymerase chain reaction (PCR)

The PCR cocktail including DNA had total volume of 14.75 μ L/reaction was placed in the PCR tubes and run in the DNA thermal cycler.

Components of PCR cocktail

The following components were used to prepare PCR cocktail (Table 2). The total volume of PCR cocktail for this study was 12.75 μ L per sample.

Table 2. Components of PCR cocktail

SL	Component	Quantity (for single reaction)
1	10 \times Buffer	1.0 μ L
2	MgCl ₂	0.5 μ L
3	dNTPs	0.75 μ L
4	Primer forward	1.0 μ L
5	Primer reverse	1.0 μ L
6	Taq polymerase	0.25 μ L
7	ddH ₂ O	8.25 μ L
Total =		12.75 μL

2 μ L genomic DNA was added with 12.75 μ L PCR cocktail and finally, total volume was 14.75 μ L.

PCR amplification profile

The PCR tubes were set on the wells of the thermo cycler plate. Then the machine was run according to the following setup

- 1) Initial denaturation at 94°C for 5 min
- 2) Denaturation at 94°C for 1 min
- 3) Annealing at respective temperature of individual primer for 1 min
- 4) Polymerization at 72°C for 2 min
- 5) Cycle to step 2 for 34 more time
- 6) Incubation at 72°C for 7 min

Polyacrylamide Gel electrophoresis for microsatellite marker analysis

Glass plate assembly

1. The plates were washed using lab detergent and rinsed with water and then air-dried or used lint-free tissue. The chosen inner surfaces of the plate set was sprayed with 95% ethanol and wiped with lint-free tissue (3x).
2. While holding the rectangular back plate with the rounded bottom corner, gasket was attached around starting from one side of the plate. The notches on the gasket were aligned on the corners; the circular portion of the gasket was exposed to the inner side of the plate.
3. The short plate was laid on the table with the tubing side up. The spacers were put along the inside edges of the gasket.
4. The other plate was put on top of the short plate.
5. The clamps were set on both sides of the plates and laid the plate assembly flat on the table. The surface of the table was even.

The gel solution was prepared in a beaker with a magnetic stirring bar. The reagents was Added as given bellow (Table 3).

Table 3. Ratio of the components of the polyacrylamide gel

Reagents	Final concentration	8% gel
ddH ₂ O	---	39 ml
50X TAE Buffer	0.5X	0.5 ml
40% Acrylamide	6-12%	10 ml
10% APS	0.1%	0.5 ml
TEMED	0.0833 µl/ml	41.5 µl
Total	---	50 ml

Gel casting

The gel was poured smoothly and continuously starting from one corner until it reached the top portion of the short plate. The comb was inserted gently such that half of it was fully inserted in the gel. The gel was allowed to polymerize for 15 minutes.

Electrophoresis

1. The gasket was removed starting from one side of the plate assembly and 1X TAE buffer was added in the base of the tank. The plate assembly was attached in one side of the tank such that the short plate was facing the inner side. The same procedure was followed on the other side. It was made sure that, there were no bubbles at the bottom to avoid short circuit. 1X TAE buffer was added on top of the tank and the comb was removed carefully.
2. About 2 µl of sample was loaded in each well. DNA size marker like 20 bp DNA ladder was used for size determination.
3. Then the tank was covered. The electrodes were connected to the power supply and run for about 2.0-2.5 hr. at 80 volts (running time may be variable depending on the size of PCR fragment).

Staining and visualization of the gel

The power supply was turned off. The plates were removed from the tank. The glass plates were separated using a plastic wedge. The polyacrylamide gel was removed and transferred it in ethidium bromide (10mg/mL) solution for 15-20 min. The stained gels were put in the exposure cabinet of the gel documentation system. The gels were viewed in the computer monitor by exposing it first to white light. The necessary adjustments were made by moving the gel inside the exposure box. The gel image resolution was adjusted using the camera setting. The gel was exposed to UV light and the gel image was saved as a jpg file.

SSR data analysis

The size of most intensely amplified fragments was determined by comparing the migration distance of amplified fragments relative to the molecular weight of known size markers, 20 base pairs (bp) DNA ladder using Alpha-Ease FC 5.0 software (Alpha Innotech, USA). The number of alleles per locus, major allele frequency, gene diversity, PIC and Nei's genetic identity and genetic distance values were calculated using PowerMarker version 3.25 (Liu and Muse, 2005). All the genotypes were scored for the presence and absence of the SSR bands throughout all 30 genotypes and the data were exported to binary data for the presence (1) or absence (0) or as a missing observation for further analysis with NTSYS-pc version 2.2. NTSYS-pc was used to construct a UPGMA (Unweighted Pair Group Method with Arithmetic Averages) dendrogram showing the distance-based interrelationship among the genotypes.

9. Results and discussion

With a view to characterize and documentation of the GI/varieties/germplasm of different crop species based on their morphological identifying characters using descriptors and photographs of some selected traits followed by assessment and identification of the some genotypes using SSR or RAPD markers were implemented in this project which are as follows:

Characterization of GI crops:

A geographical indication (GI) crop is referred to that crop which is grown in specific location or origin and possess qualities/characteristics that are essentially attributable to that place of origin. Most commonly, a geographical indication includes the name of the place of origin of the goods. Agricultural products typically have qualities that derive from their place of production and are influenced by specific local factors, such as climate and soil.

Characterization of GI crops for BINA part is Mungbean(Sonamoog), Blackgram(Kalikolai) and Sesame (Local til).

Crop: Mungbean (*Vigna radiata*)

Historical background: This cultivar of mungbean is sporadically cultivated in Mymensingh, Rajshahi, Kishorgong, Gaibanda, Pabna, Barisal, Rajbari, Faridpur, Jessore, Thakurgaon, Charland of different districts. A gentle man specially named Ismail Munshi, age of 91 years of Mymensingh now informed us, they were cultivated local moog specially sonamoog. "Moogdal (Sonamoog) was an integral part of our food menu from our ancient history of Bengali food. Still today we can't separate it from every kind of Ceremonial dish. Among the pulse, Sonamoog dal was always treated as specialized menu". They also informed that they collected seeds from local market, neighbours, from their father, fore father and from different parts of Bangladesh (Fig. 1).

Passport descriptors:

Variety/Cultivar : **Sonamoog**
Collecting Institute : Bangladesh Institute of Nuclear Agriculture
Country of origin : Bangladesh
Name of Farmers : 1. Md. Ismail Munshi
2. Md. Alauddin

Location of collecting site: Village: Char Kalibari, Upazilla: Sadar and District: Mymensingh
Commercial value: High

Area coverage: Mymensingh, Rajshahi, Kishorgong, Gaibanda, Pabna , Barisal, Dinajpur, Rajbari, Faridpur, Jessore, Thakurgaon, Charland rivers and a few of some other districts.

Food items prepared from Sonamoog: Dal, Hotchpotch (mixture of rice and moogdal), Murighonto(fish head cooked with Sonamoog), dal chorchori (a cooked preparation of intact mungbean seed).

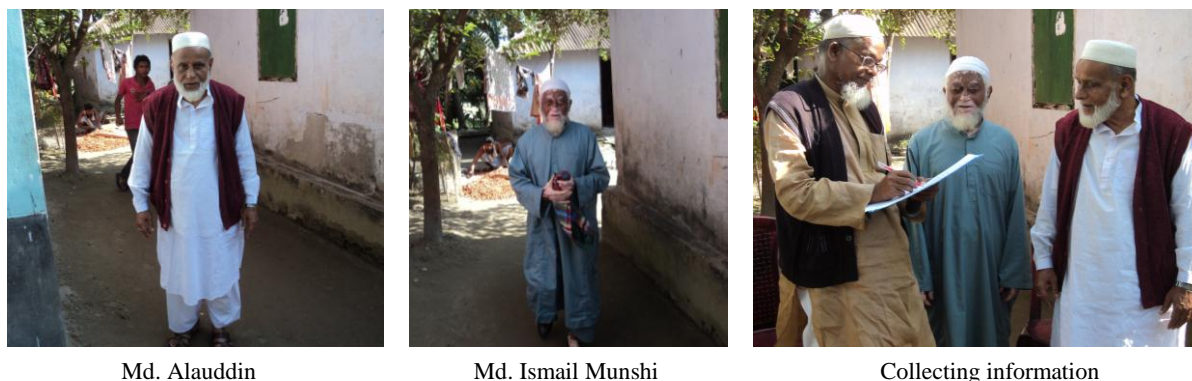


Fig. 1. Collecting information regarding Sonamoog (GI) crop from Mymensingh District

Morphological Characterization of Sonamoog (GI crop)

Morphological characterization of Sonamoog (GI crop) has been done. Passport information of plant and leaf characteristics of the crop has been recorded. Sonamoog is termed as various names in different locations as Deshi moog, Ghassi moog, Shonamukhi moog, Jamai pasanda moog. Technical report achieved so far is presented below (Table 4 and Fig. 2).

Table 4. Distinctness of the morphological characters of Sonamoog

Sl. No.	State of the characters	Sonamoog
1.	Growth habit	Semi-erect
2.	Growth pattern	Determinate
3.	Leaves	Ovate
4.	Terminal leaflet length	Small
5.	Leaf pubescence	Glabrous
6.	Leaf colour	Light green
7.	Petiole colour	Green
8.	Petiole length	Short
9.	Leaf senescence	Not visibly senescence
10.	Raceme position	No pods visible above canopy
11.	Calyx colour	Green
12.	Corolla colour	Light yellow
13.	Pod colour at immature stage	Light green
14.	Colour of ventral suture of immature pod	Deep green
15.	Pod colour at mature stage	Brown
16.	Shape of ripe pod	Round
17.	Pod length (cm)	7.0
18.	Pod pubescence	Absent
19.	Constriction of pod between seed	Present
20.	Pod curvature	Least curve
21.	Seed colour	Yellow
22.	Mottling of seeds	Absent
23.	Seed shape	Drum shaped
24.	Number of pods	13-15
25.	Plant height (cm)	40-45
26.	Yield/plant (g)	4.5

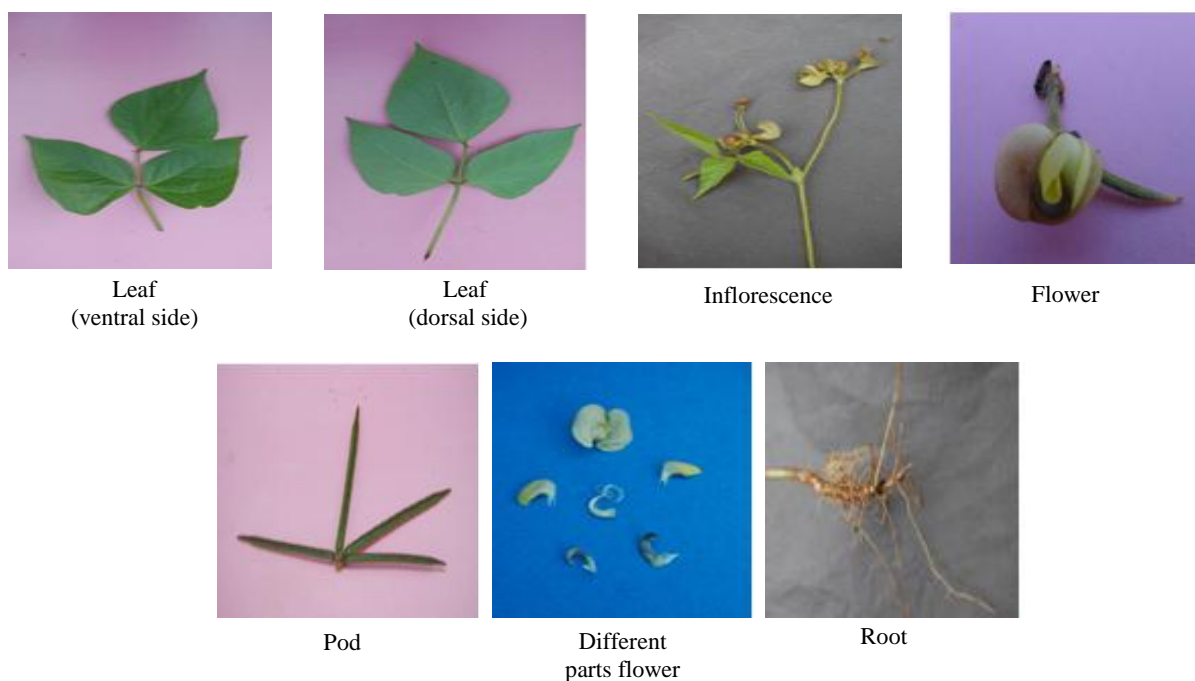


Fig. 2. Photograph showing different parts of Sonamoog (GI crop)

Molecular Characterization of sonamoog (GI crop)

Sonamoog (GI crop) was analyzed using SSR markers. The five primers initially tested among them, two primers (**MBSSR41** and **MBSSR60**) produced amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of SSR markers is shown in Fig. 3. Single allele per locus was detected in Sonamoog crop by using MBSSR41 and MBSSR60 primer. MBSSR41 primer gave the product of 210bp allele size while MBSSR60 produced the allele size range 165 bp.

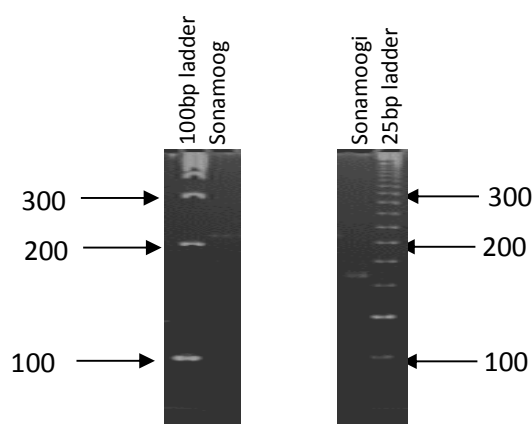


Fig. 3. Microsatellite profiles of Sonamoog at loci MBSSR41 and MBSSR60

Crop: Sesame (*Sesamum indicum*)

Historical background: This cultivars of Local til (GI crop) is sporadically cultivated in Sirajgonj, Mymensingh, Rajshahi, Pabna, Rajbari, Chalan Bil and a few places of some other districts. More than 200 years ago Local til cultivation started. A gentle man specially named Md. Abdul Hadi Talukder age of 85 years of Sirajgonj informed us they collected seeds from local market, neibours, own collection from their father, grandfather and forefather (Fig. 4).



Md. Abdul Hadi Talukder



Collecting information

Fig. 4. Collecting information regarding Local til (GI crop) from Sirajgonj District

Passport descriptors

Variety/Cultivar: **Local til**

Collecting Institute: Bangladesh Institute of Nuclear Agriculture

Country of origin: Bangladesh

Name of farmers: 1. Md. Abdul Hadi Talukder

Location of collecting site: Village: 1. Char Darshika Union, kamarkhand Upazilla and district of Sirajgonj

Commercial value: Medium

Cultivation practices: Homestead area and some charland

Area coverage: Sirajgonj, Mymensingh, Rajshahi, Pabna, Rajbari, Chalan Bil, Char of Jamuna

Food items prepared from Local til: Local til is widely used in a various food item from long time ago. For example, Tiler naru (A form of ball made from dehusked sesame seed with molasses), Tiler khaja (a rectangular sized thin preparation, sugar sweetened dehusked sesame seeds pasted on the layer of wheat flour), Tiler bhorta (special mash preparation), Tiler toil (better quality oil) used both for consumption and medicine purpose for rapid healing of pox patient.

Morphological Characterization of Local til (GI crop)

Morphological characterization of local til (GI crop) has been done. Passport information and plant and leaf characteristics of the crop have been recorded. This local til is termed as various names in different locations as Dashi til, Boro til, Goji til, Doi shira til, char shira til, Kalo til, Dhanya til. Technical report achieved so far is presented below (Table 5 & Fig. 5).

Table 5. Distinctness of the morphological characters of Local til

Sl. No.	State of the characters	Local til
1.	Branching habit	Branching
2.	Leaf position	Alternate
3.	Growth	Indeterminate
4.	Capsule shape	Narrow oblong
5.	Shattering in the field	Shattered
6.	Seed coat colour	Brown
7.	Number of flowers per leaf axil	1
8.	Number of nodes to first flower	5-7
9.	Internode length (cm)	4.5
10.	Capsule length (cm)	1.8-2.0
11.	Seeds per capsule	45-50
12.	Number of pods/plant	50-55
13.	1000 -seed weight (g)	2.1 -2.5
14.	Yield/plant (g)	10-12



Fig. 5. Photograph showing different parts of Local til (GI crop)

Molecular Characterization of Local til (GI crop) using RAPD markers

Local til (GI crop) was analyzed using RAPD markers. The five primers initially tested among them, two primers (**OPA02 and OPB 06**) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of RAPD markers is shown in Fig. 6. Til Laxmi and Til Raj showed 5 alleles and 7 alleles per locus, respectively by Primer OPA02 and OPB06.

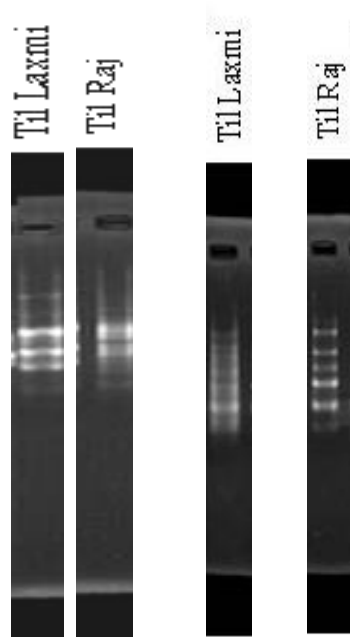


Fig. 6. RAPD profile of Local til (GI crop) using primers OPA02 and OPB 06

Crop: Blackgram (*Vigna mungo*)

Historical background: This cultivars of blackgram (Mashkolai) is sporadically cultivated in Mymensingh, Rajshahi, Barisal, Gaybanda, Pabna, Rajbari, Char of Jamuna, Brahamatraputra and other riviers. From very ancient time blackgram (Mashkolai) cultivation started. Some gentleman specially named Md. Abdus Satter bishwas age of 90 years of Pabna and Md. Abdus Satter Mondal age of 80 years of Rajshahi districts informed us, they collected seeds from local market, neibours, own collection from their father, grandfather and forefather and some other places (Fig. 7).



Md. Abdus Satter bishwas



Collecting information



Md. Abdus Satter Mondal



Collecting information

Fig. 7. Collecting information regarding Kalikolai (GI crop) from Pabna and Rajshahi Districts

Passport descriptors

Variety/Cultivar: **Kalikolai**

Collecting Institute: Bangladesh Institute of Nuclear Agriculture

Country of origin: Bangladesh

Name of farmers: 1) Md. Abdus Satter bishwas, 2) Md. Abdus Satter Mondal

Location of collecting site: Village: 1. Aron kola Union, Ishurdi Upazilla and district of Pabna
2. Rajabari Union, Godagari Upazilla and district of Rajshahi

Commercial value: High

Cultivation practices: High, medium high and charl and

Area coverage: Sirajgonj, Mymensingh, Rajshahi, Gaybanda, Pabna, Rajbari, some other districts and charlands.

Food items prepared from Mashkolai: Mashkolai is widely used as a various form of food item in different locations of Bangladesh especially in Rajshahi region. For example, common use of blackgram as dal, dal bori (a small ball preparation from dried mash mixed with goured), mash bread (a bread preparation from the mixture of mash and wheat flour).

Morphological Characteristic of GI crop (Kalikolai)

Morphological characterization of blackgram (Mashkolai) crop (GI) has been initiated. Passport information and plant and leaf characteristics of the crop have been recorded. This mashkolai is termed as various names in different locations as Moishakolai, Thakurikolai, Kalikolai etc. Technical report achieved so far is presented below (Table 6 and Fig. 8).

Table 6. Distinctness of the morphological characters of Kalikolai

Sl. No.	State of the characters	Kalikolai
1.	Growth habit	Semi-erect/ Spreading
2.	Growth pattern	Determinate / Indeterminate
3.	Leave	Acute/Cuneate
4.	Terminal leaflet length	Medium
5.	Leaf pubescence	Pubescent
6.	Leaf colour	Light green
7.	Petiole colour	Green
8.	Petiole length	Short
9.	Leaf senescence	Not visibly senescence
10.	Raceme position	No pods visible above canopy
11.	Calyx colour	Green
12.	Corolla colour	Deep yellow
13.	Pod colour at immature stage	Light green
14.	Pod colour at mature stage	Black
15.	Shape of ripe pod	Round
16.	Pod length (cm)	4.0
17.	Pod pubescence	Present
18.	Constriction of pod between seed	Present
19.	Pod curvature	Least curve
20.	Seeds	Black
21.	Mottling of seeds	Absent
22.	Seed shape	Drum shaped
23.	Number of pods	20/90
24.	Plant height (cm)	134 /68.5/36.5
25.	Yield/plant (g)	4.5



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Different parts flower



Fruit bearing



Root

Fig. 8. Photograph showing different parts of Kalikolai (GI crop)

Molecular Characterization of Kalikolai (GI crop) using RAPD markers

Kalikolai (GI crop) was analyzed using RAPD markers. The seven primers initially tested among them, two primers (**OPA02 and OPB 06**) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of RAPD markers is shown in Fig. 9.

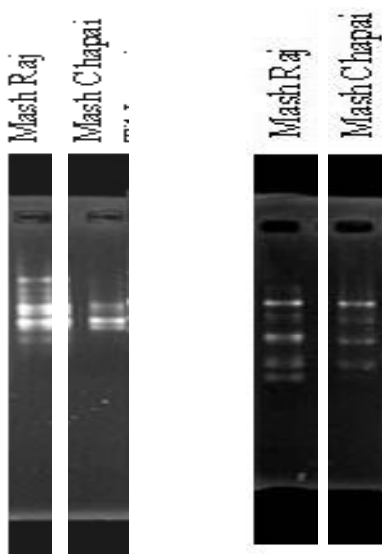


Fig. 9. RAPD profile of Kalikolai (GI) crop using primers OPA02 and OPB 06

Crop: Groundnut (*Arachis hypogaea*)

Morphological Characterization of Groundnut varieties and germplasm

To characterize groundnut varieties/germplasm morphologically, this experiment was laid out with 6 groundnut varieties and 8 germplasm at BINA Head quarter farm during Kharif-1 season. The experiment was followed by RCB design with three replications. Seeds were sown on January 2013 at 15 cm distances within rows of 30 cm apart. A unit plot size was 1.2 m x 1.05m. Recommended doses of fertilizer were applied and cultural and intercultural operations were also followed. Morphological characterization and identification of the traits of documentation for distinctness of the varieties/germplasm were recorded from the field using the approved descriptors of IBPGR and IPGRI. All the data and photograph are presented in Table 7 & 8 and Fig. 10 & 11.

Growth habit of Binachinabadam-1, Binachinabadam-2 and Binachinabadam-4 is procumbent; Binachinabadam-3, Binachinabadam-5 and Binachinabadam-6 is decumbent and other tested germplasm are erect. Variation was observed in BINA groundnut varieties and germplasm with respect to leaf and petal colour.

Table 7. Distinctness of the morphological characters of groundnut varieties

Sl. No.	State of the characters	Binachina badam-1	Binachina badam-2	Binachina badam-3	Binachina badam-4	Binachina badam-5	Binachina badam-6
1.	Growth habit	Procumbent	Procumbent	Decumbent	Procumbent	Decumbent	Decumbent
2.	Branching pattern	Irregular with flowers on main stem	Irregular with flowers on main stem	Irregular with flowers on main stem	Irregular with flowers on main stem	Irregular with flowers on main stem	Irregular with flowers on main stem
3.	Leaf	Green	Dark green	Dark green	Dull green	Green	Light green
4.	Stem pigmentation	No	No	No	No	No	No
5.	Stem hairiness	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse
6.	Lateral branches	4	No	No	No	No	No
7.	Peg colour	Light purple	Light purple	Light purple	Light purple	Light purple	Light purple
8.	Standard petal colour	Orange	Orange	Orange	Orange	Deep yellow	Light yellow
9.	Pod reticulation	Prominent	Prominent	Prominent	Prominent	Prominent	Prominent
10.	Plant height (cm)	22.2-26.8	17.9-21.9	15.2-19.6	23-27	21-27	22-27
11.	No. of flower/ inflorescence	1	1	1	1	1	1
12.	Days to 50% flowering	70-76 (Winter) 41-46 (Summer)	70-77 (Winter) 43-48 (Summer)	72-78 (Winter) 44-48 (Summer)	70-80 (Winter) 40-45 (Summer)	70 (Winter) 40-45 (Summer)	71 (Winter) 40-45 (Summer)
13.	Days to maturity	150-160	150-160	150-160	140-145	140-150	140-150
14.	Pods/plant	13-18	16-19	16-19	20-22	19-21	19-23
15.	Number of seeds/pod	2	2	2	2	2	2
16.	100-Seed weight (g)	77.1-76.2	76.5-77.2	76.2-77.3	58.3-59.6	58.7-60.2	59.6-60.7
17.	Pod yield/plant (g)	20-22	15-17	21-22	15-17	13-16	15-17
18.	Fresh seed dormancy (%)	100	100	100	100	100	100
19.	Seed dormancy (%)	100	97	95	92	100	95
20.	Shelling (%)	70	70	70	72	75	75



Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

Binachinabadam-1



Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

Binachinabadam-2

10. Photograph showing different parts of groundnut varieties



Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing abit

Binachinabadam-3



Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing abit

Binachinabadam-4

Fig. 10. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing abit

Binachinabadam-5



Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing abit

Binachinabadam-6

Fig. 10. Cont'd

Table 8. Distinctness of the morphological characters of groundnut germplasm

Sl. No.	State of the characters	D1-20-17-1	CG(1)-24-1-1-1	CG(1)-4-1	GC(1)-35-1-1
1.	Growth habit	Erect	Erect	Erect	Erect
2.	Branching pattern	Irregular	Irregular	Alternate	Irregular
3.	Leaf	Light green	Green	Light green	Light green
4.	Stem pigmentation	No	No	No	No
5.	Stem hairiness	Sparse	Sparse	Abundant	Sparse
6.	Lateral Branches	No	No	No	No
7.	Peg colour	Green	Green	Green	Green
8.	Standard petal colour	Deep yellow	Deep yellow	Deep yellow	Deep yellow
9.	Pod reticulation	Prominent	Smooth	Prominent	Prominent
10.	Plant height (cm)	90	69	74	73
11.	No. of flower/ inflorescence	1	1	1	1
12.	Days to 50% flowering	70-76 (Winter) 41-45 (Summer)	71-77 (Winter) 42-47 (Summer)	72-78 (Winter) 43-48 (Summer)	70-80 (Winter) 42-45 (Summer)
13.	Days to maturity	141-147 (Winter) 111-118 (Summer)	143-150 (Winter) 113-119 (Summer)	142-148 (Winter) 112-118 (Summer)	140-150 (Winter) 109-116 (Summer)
14.	No. of pods/plant	12.0	12.7	10.4	13.3
15.	No. of seeds/pod	1.9	1.8	2	1.8
16.	100-Seed weight (g)	34	35	32	32
17.	Pod yield/plant (gm)	12-13	12-14	12-13	12-13
18.	Fresh seed dormancy (%)	100	100	100	100
19.	Seed dormancy (%)	100	98	100	90
20.	Shelling (%)	65-70	75-90	80-90	65-85

Table 8. Cont'd

Sl. No.	State of the characters	CG(1)-32-3-1-1	RS-25-3-1	CG(1)-32-2-1-2	GC(1)-39-1-2
1.	Growth habit	Erect	Erect	Erect	Erect
2.	Branching pattern	Irregular	Irregular	Irregular	Irregular
3.	Leaf				
4.	Stem pigmentation	No	No	No	No
5.	Stem hairiness	Sparse	Abundant	Sparse	Abundant
6.	Lateral Branches	No	No	No	No
7.	Peg colour	Green	Green	Green	Green
8.	Standard petal colour	Deep yellow	Light yellow	Deep yellow	Orange
9.	Pod reticulation	Prominent	Prominent	Prominent	Moderate
10.	Plant height (cm)	92	68	78	73
11.	No. of flower/ inflorescence	1	1	1	1
12.	Days to 50% flowering	70-75 (Winter) 41-46 (Summer)	71-78 (Winter) 43-48 (Summer)	72-77 (Winter) 44-48 (Summer)	72-80 (Winter) 40-45 (Summer)
13.	Days to maturity	135-145 (Winter) 108-115 (Summer)	145-150 (Winter) 110-116 (Summer)	140-148 (Winter) 107-113 (Summer)	142-147 (Winter) 110-115 (Summer)
14.	Number of pods/plant	2	2	1.9	2
15.	Number of seeds/pod	2.0	1.7	1.9	1.6
16.	100-Seed weight (g)	33	34	31	34
17.	Pod yield/plant (g)	12-14	11-14	12-14	13-16
18.	Fresh seed dormancy (%)	100	100	100	100
19.	Seed dormancy (%)	98	96	97	95
20.	Shelling (%)	60-78	66-90	71-90	65-75



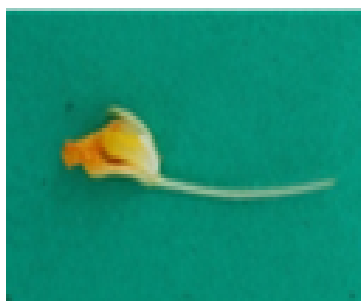
Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

D1/20/17-1



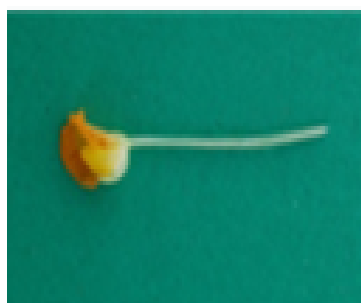
Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

CG (1)-24-1-1-1

Fig. 11. Photograph showing different parts of groundnut germplasm



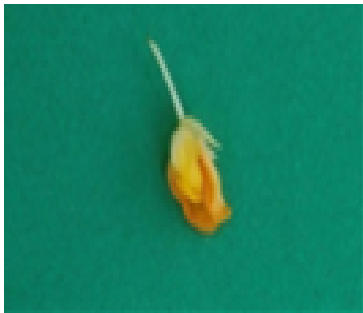
Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

CG (1)-4-1



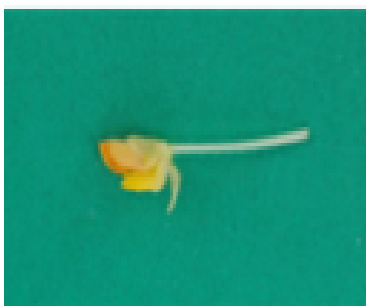
Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

CG (1)-35-1-1

Fig. 11. Cont'd



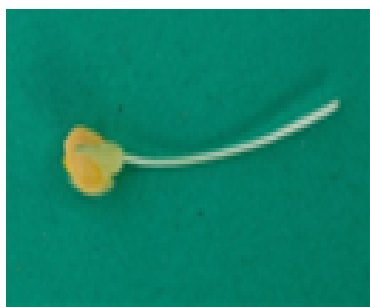
Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

CG (1)-32-3-1-1



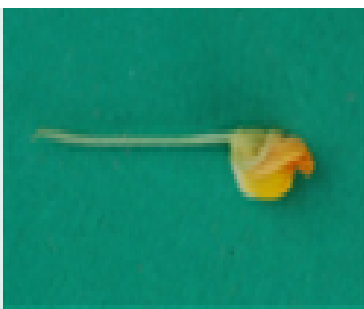
Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

RS/25/3-1

Fig. 11. Cont'd



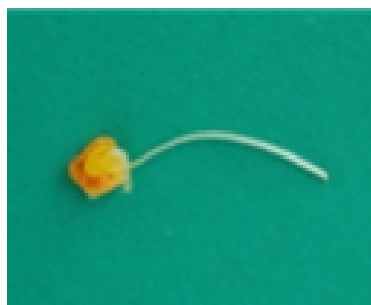
Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

CG (1)-32-2-1-2



Leaf (ventral side)



Leaf (dorsal side)



Branch



Flower



Fruit



Fruit bearing habit

CG (1)-39-1-2

Fig. 11. Cont'd

Molecular characterization of four groundnut varieties using SSR and RAPD markers

Out of six, 4 groundnut varieties were analyzed by using SSR and RAPD markers and others were not genotyped because of time constraints. But the genotyping will be continued even after project completion. The five primers initially tested among them, two primers (**SSR 145** and **OPC01**) produced amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of SSR and RAPD markers is shown in Figs. 12a & 12b.

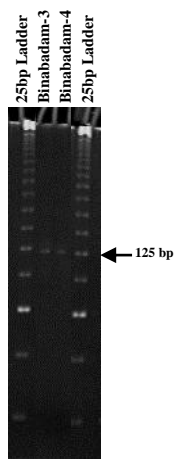


Fig. 12a. SSR profile of Binadadam-3 and Binabadam-4 using primer SSR 145

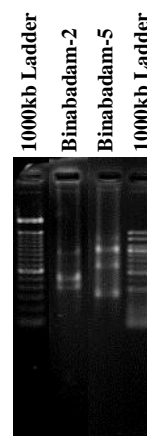


Fig. 12b. RAPD profile of Binabadam-2 and Binabadam-5 using primer OPC01

Crop: Mungbean (*Vigna radiata*)

Morphological Characteristic of Mungbean varieties and germplasm

An experiment was carried out with 7 mungbean released varieties (out of 8) and 27 germplasm (based on availability, instead of 12 germplasm 27 were taken) at BINA Head Quarter farm, Mymensingh during Rabi and Kharif-1 season of 2011-12 for characterization and documentation morphologically. Seeds were sown in RCB design with three replications. Unit plot size was 1.2 m × 3m. Row to row and plant to plant distances were 40 cm and 10 cm, respectively. Recommended fertilizer doses were applied. Data on all the traits in the descriptor (IBPGR/IPGRI) were recorded and photograph taken from the field and presented in Tables 9-11 and Fig. 13 & 14.

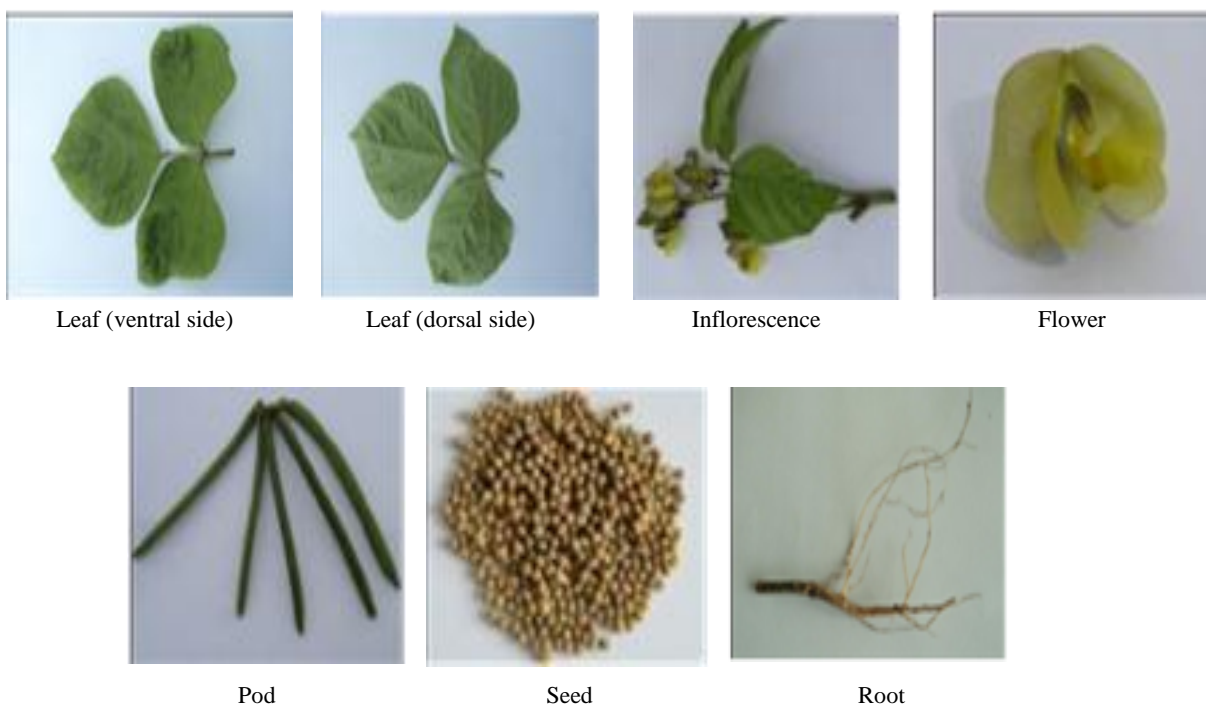
Wide variation (green, purple, greenish purple) was observed in colour of leaf blade joint, petiole and basal petioles among the varieties and genotypes of mungbean. Some genotypes possess semi-erect and some are erect growth habit. There were variations in seed shape and colour among the varieties and germplasm.

Table 9. Distinctness of the morphological characters of summer mungbean varieties

Sl. No.	State of the characters	Binamoog-2	Binamoog-5	Binamoog-6	Binamoog-7	Binamoog-8
1.	Growth habit	Semi-erect	Erect	Semi-erect	Semi-erect	Erect
2.	Growth pattern	Determinate	Determinate	Determinate	Determinate	Determinate
3.	Leaves	Ovate	Ovate	Ovate	Ovate	Ovate
4.	Terminal leaflet length	Small	Small	Small	Small	Small
5.	Leaf pubescence	Pubescent	Pubescent	Pubescent	Pubescent	Pubescent
6.	Leaf colour	Light green	Light green	Dark green	Light green	Dark green
7.	Petiole colour	Green	Green	Green	Green	Green
8.	Petiole length	Short	Short	Short	Short	Short
9.	Leaf senescence	Not visibly senescence	Not visibly senescence	Not visibly senescence	Not visibly senescence	Not visibly senescence
10.	Raceme position	No pods visible above canopy	Pods visible above canopy	No pods visible above canopy	No pods visible above canopy	No pods visible above canopy
11.	Calyx colour	Green	Green	Green	Green	Green
12.	Corolla colour	Light green	Light green	Light green	Light green	Light green
13.	Pod colour at immature stage	Light green	Light green	Green	Light green	Green
14.	Colour of ventral suture of immature pod	Green	Green	Green	Green	Dark green
15.	Pod colour at mature stage	Brown	Dark Brown	Black	Dark Brown	Black
16.	Shape of ripe pod	Round	Round	Round	Round	Round
17.	Pod length (cm)	7-9	10-12	10-12	7-9	11-13
18.	Pod pubescence	Absent	Absent	Absent	Absent	Absent
19.	Constriction of pod between seed	Present	Present	Present	Present	Present
20.	Pod curvature	Least curve	curve	curve	Least curve	Narrow-oblong
21.	Seed colour	Light green	green	green	Light green	Dark green
22.	Mottling of seeds	Absent	Absent	Absent	Absent	Absent
23.	Seed shape	Drum shaped	Bold semi-round	Drum shaped	Drum shaped	Drum shaped
24.	Number of pods	20-35	35-45	25-40	30-45	35-50
25.	Plant height (cm)	35-45	40-50	30-40	35-45	40-50
26.	Yield/plant (g)	6.8	7.8	7.6	7.3	7.8

Table 10. Distinctness of the morphological characters of winter mungbean varieties

Sl. No.	State of the characters	Binamoog-1	Binamoog-4
1.	Growth habit	Semi-erect	Semi-erect
2.	Growth pattern	Determinate	Determinate
3.	Leaves	Ovate	Ovate
4.	Terminal leaflet length	Small	Small
5.	Leaf pubescence	Pubescent	Glabrous
6.	Leaf colour	Light green	Dark green
7.	Petiole colour	Green	Green
8.	Petiole length	Short	Short
9.	Leaf senescence	Not visibly senescence	Not visibly senescence
10.	Raceme position	No pods visible above canopy	Mostly above canopy
11.	Calyx colour	Green	Green
12.	Corolla colour	Light yellow	Light yellow
13.	Pod colour at immature stage	Light green	green
14.	Colour of ventral suture of immature pod	Deep green	green
15.	Pod colour at mature stage	Brown	Black
16.	Shape of ripe pod	Round	Round
17.	Pod length (cm)	10.0	11.0
18.	Pod pubescence	Absent	Absent
19.	Constriction of pod between seed	Present	Present
20.	Pod curvature	Least curve	Least curve
21.	Seed colour	Yellow	Green
22.	Mottling of seeds	Absent	Absent
23.	Seed shape	Drum shaped	Drum shaped
24.	Number of pods	40-45	30-35
25.	Plant height (cm)	40-45	30-35
26.	Yield/plant (g)	7.5	6.8



Binamoog-1

Fig. 13. Photograph showing different parts of mungbean varieties



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

Binamoog-2



Leaf (ventral side)



Leaf (dorsal side)



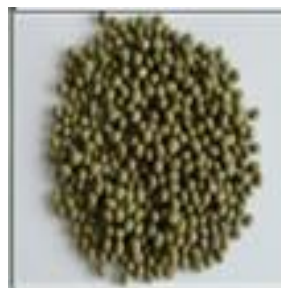
Inflorescence



Flower



Pod



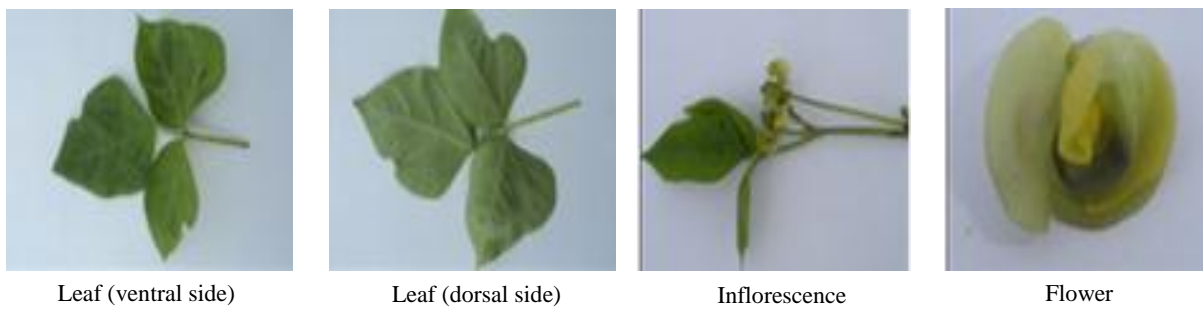
Seed



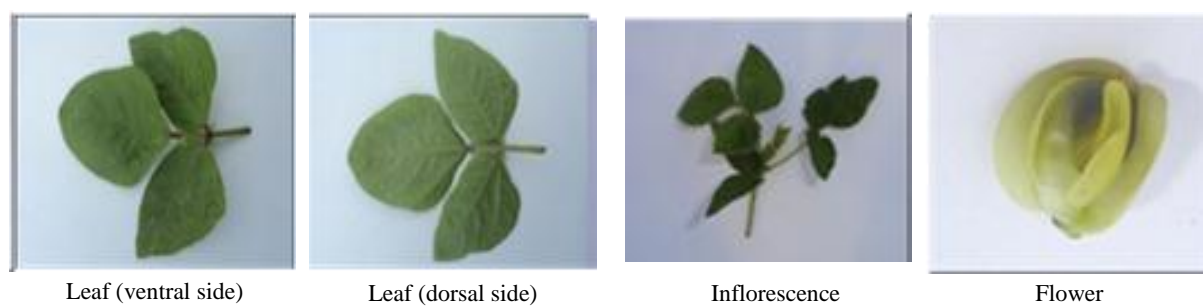
Root

Binamoog-4

Fig. 13. Cont'd



Binamoog-5



Binamoog-6

Fig. 13. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

Binamoog-7



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

Binamoog-8

Fig. 13. Cont'd

Table 11. Distinctness of the morphological characters of mungbean germplasm

Variety/ germplasm	Growth pattern	Hypocotyl colour	Leaves pubescence	Terminal leaflet length (cm)	Colour of leaf blade joint	Petiole colour	Colour of basal petioles
AVRDC 01	Indeterminate	Purple	Glabrous	11	Purple	Green	Green
AVRDC 02	Determinant	Greenish purple	Pubescence	8	Green	Green	Green
AVRDC 03	Indeterminate	Purple	Pubescence	7	Green	Light green	Green
AVRDC 04	Indeterminate	Purple	Pubescence	11	Green	Green	Green
AVRDC 05	Indeterminate	Purple	Pubescence	8	Green	Greenish purple	Purple
AVRDC 06	Indeterminate	Purple	Pubescence	7	Purple	Greenish Purple	Purple
AVRDC 07	Determinate	Greenish purple	Pubescence	7	Purple	Green	Green
AVRDC 08	Indeterminate	Purple	Pubescence	6	Green	Green	Green
AVRDC 09	Indeterminate	Purple	Pubescence	6	Green	Green	Green
AVRDC 10	Indeterminate	Purple	Pubescence	7	Green	Green	Green
AVRDC 11	Indeterminate	Purple	Pubescence	7	Purple	Greenish Purple	Purple
AVRDC 12	Indeterminate	purple	Pubescence	5	Green	Green	Green
AVRDC 13	Determinate	Greenish purple	Pubescence	6	Green	Green	Green
AVRDC 14	Indeterminate	purple	Pubescence	5	Greenish Purple	Greenish Purple	Purple
AVRDC 15	Indeterminate	Purple	Pubescence	9	Greenish Purple	Greenish Purple	Purple
MBM-390-94	Indeterminate	Purple	Pubescence	6	Purple	Greenish Purple	Purple
MBM-657	Determinate	Purple	Pubescence	7	Purple	Greenish Purple	Purple
MBM-527-114	Indeterminate	Greenish purple	Pubescence	5	Greenish Purple	Green	Green
MBM-573-69	Indeterminate	Purple	Pubescence	7	Purple	Greenish Purple	Purple
MBM-289-4	Indeterminate	Purple	Pubescence	6	Purple	Greenish Purple	Purple
MBM-656-51(2)	Determinate	Purple	Pubescence	7	Purple	Purple	Purple
MBM-346-13	Indeterminate	Purple	Pubescence	8	Purple	Greenish Purple	Purple
MBM-477-60	Indeterminate	Purple	Pubescence	7	Purple	Greenish Purple	Purple
MBM-07 (seg)	Indeterminate	Purple	Pubescence	6	Purple	Greenish Purple	Purple
MBM-427-87	Determinate	Purple	Pubescence	7	Purple	Purple	Purple
MBM-590-93	Indeterminate	Purple	Pubescence	8	Purple	Greenish Purple	Purple
MBM-508-67	Indeterminate	Purple	Pubescence	7	Purple	Greenish Purple	Purple

Table 11. Cont'd

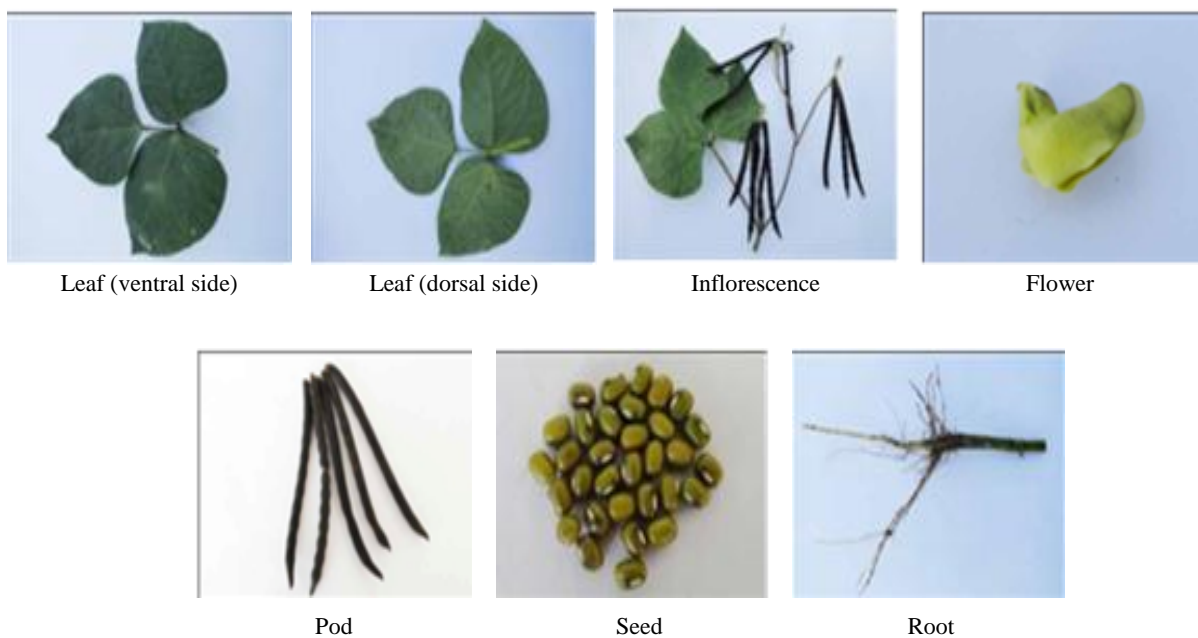
Variety/ germplasm	Petiole length	Leaf senescence	Length of peduncle	Raceme position	Calyx colour	Corolla colour	Pod colour immature stage
AVRDC 01	Medium	Not visible	Medium	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 02	Short	Intermediate	Medium	Mostly above canopy	Green	Light yellow	Light green
AVRDC 03	Short	Not visible	Short	Mostly above canopy	Green	Greenish yellow	Green
AVRDC 04	Short	Not visible	Medium	Mostly above canopy	Green	Greenish yellow	Light Green
AVRDC 05	Medium	Not visible	Medium	Intern nodiote	Green	Light yellow	Light green
AVRDC 06	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 07	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 08	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 09	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 10	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 11	Short	Not visible	Short	Mostly above canopy	Greenish purple	Light yellow	Light green
AVRDC 12	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 13	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
AVRDC 14	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Light yellow	Light Green
AVRDC 15	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-390-94	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-657	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-527-114	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-573-69	Medium	Not visible	Medium	Mostly above canopy	Greenish purple	Greenish yellow	Light Green
MBM-289-4	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-656-51(2)	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light Green
MBM-346-13	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-477-60	Medium	Not visible	Medium	Mostly above canopy	Greenish purple	Greenish yellow	Light Green
MBM-07 (seg)	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-427-87	Short	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light Green
MBM-590-93	Medium	Not visible	Short	Mostly above canopy	Greenish purple	Greenish yellow	Light green
MBM-508-67	Medium	Not visible	Medium	Mostly above canopy	Greenish purple	Greenish yellow	Light Green

Table 11. Cont'd

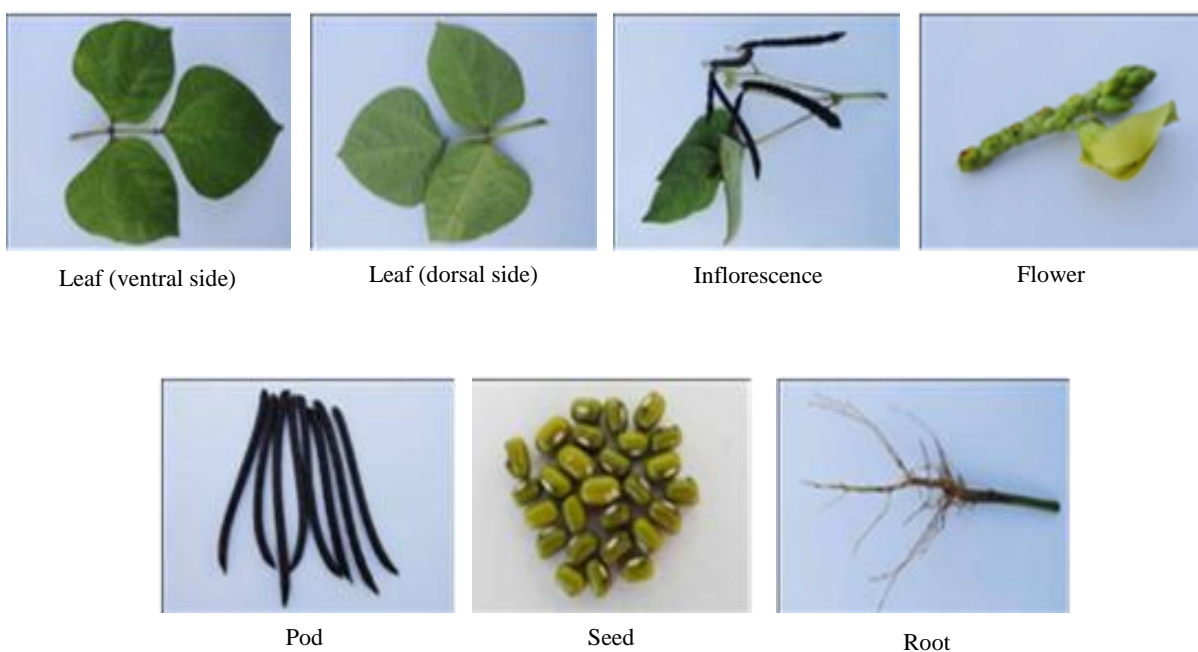
Variety/ germplasm	Pod colour mature stage	Shape ripe pod	Pod length (cm)	Seed colour	Seed shape	No. of branches/ plant	Leafiness
AVRDC 01	Black	Semi flat	10	Greenish yellow	Round	3	Sparse
AVRDC 02	Black	Semi flat	8.2	Brown	Round	3	Sparse
AVRDC 03	Black	Semi flat	6	Light green	Round	3	Medium
AVRDC 04	Black	Round	10	Green	Round	3	Medium
AVRDC 05	Black	Semi flat	7	Green	Round	2	Sparse
AVRDC 06	Black	Semi flat	11	Brown	Round	3	Medium
AVRDC 07	Black	Semi flat	7	Brown	Round	0	Sparse
AVRDC 08	Black	Semi flat	5	Brown	Round	3	Medium
AVRDC 09	Black	Semi flat	9	Brown	Round	3	Medium
AVRDC 10	Black	Semi flat	7	Brown	Round	3	Abundant
AVRDC 11	Black	Semi flat	7.5	Brown	Round	4	Medium
AVRDC 12	Black	Semi flat	6.2	Brown	Round	4	Abundant
AVRDC 13	Black	Semi flat	6	Brown	Round	3	Abundant
AVRDC 14	Black	Semi flat	5.2	Brown	Round	5	Abundant
AVRDC 15	Black	Semi flat	5	Brown	Round	2	Medium
MBM-390-94	Black	Semi flat	5	Brown	Round	3	Abundant
MBM-657	Black	Round	6.5	Brown	Round	2	Abundant
MBM-527-114	Black	Semi flat	7	Brown	Round	4	Sparse
MBM-573-69	Black	Semi flat	7.5	Brown	Round	4	Abundant
MBM-289-4	Black	Semi flat	7	Brown	Round	2	Medium
MBM-656-51(2)	Black	Semi flat	7	Brown	Round	2	Abundant
MBM-346-13	Black	Semi flat	6	Brown	Round	2	Medium
MBM-477-60	Black	Semi flat	8	Brown	Round	4	Abundant
MBM-07 (seg.)	Black	Semi flat	8	Brown	Round	4	Medium
MBM-427-87	Black	Semi flat	8	Brown	Round	1	Sparse
MBM-590-93	Black	Semi flat	7	Brown	Round	2	Medium
MBM-508-67	Black	Semi flat	7	Brown	Round	2	Sparse

Table 11. Cont'd

Characteristics/ Variety/ germplasm	Colour of flower	Days to first flowering	Days to 50 % flowering	No. of pod/ plant	No. of seed/pod	100 seed weight (g)	Yield/ plant (g)
AVRDC 01	Yellowish	39	43	22	11	5.05	5.30
AVRDC 02	Yellowish	40	45	17	11	5.22	4.47
AVRDC 03	Yellowish	40	46	19	9	4.48	2.26
AVRDC 04	Yellowish	40	45	17	13	6.35	3.03
AVRDC 05	Yellowish	39	44	19	10	4.38	6.84
AVRDC 06	Yellowish	35	42	17	12	4.39	5.60
AVRDC 07	Yellowish	37	43	22	12	5.58	4.04
AVRDC 08	Yellowish	40	47	18	10	3.00	4.03
AVRDC 09	Yellowish	36	42	14	9	3.59	5.60
AVRDC 10	Yellowish	39	45	21	8	2.65	2.23
AVRDC 11	Yellowish	35	40	15	9	3.78	5.52
AVRDC 12	Yellowish	40	45	11	12	4.46	5.30
AVRDC 13	Yellowish	37	43	15	10	2.81	5.85
AVRDC 14	Yellowish	36	40	16	9	2.00	3.90
AVRDC 15	Yellowish	38	42	21	8	2.27	4.82
MBM-390-94	Yellowish	37	43	17	8	2.66	5.20
MBM-657	Yellowish	37	43	25	11	3.62	4.53
MBM-527-114	Yellowish	37	44	24	11	5.05	3.47
MBM-573-69	Yellowish	39	44	15	11	5.22	2.93
MBM-289-4	Yellowish	35	41	15	8	4.12	4.82
MBM-656-51(2)	Yellowish	37	42	16	10	3.18	4.72
MBM-346-13	Yellowish	40	44	16	12	3.75	2.26
MBM-07 (seg.)	Yellowish	38	44	18	12	3.46	4.34
MBM-477-60	Yellowish	39	43	20	13	4.00	4.60
MBM-427-87	Yellowish	36	41	22	9	2.67	5.50
MBM-590-93	Yellowish	36	42	17	10	2.34	5.10
MBM-508-67	Yellowish	36	43	24	10	2.14	2.13



AVRDC-01



AVRDC-02

Fig. 14. Photograph showing different parts of mungbean germplasm



Leaf (ventral side)



Leaf (dorsal side)



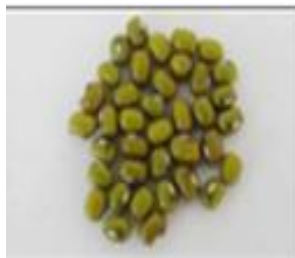
Inflorescence



Flower



Pod



Seed



Root

AVRDC-03



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-04

Fig. 14. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-05



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-06

Fig. 14. Cont'd



Leaf (ventral side)

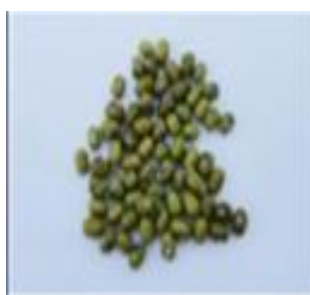
Leaf (dorsal side)

Inflorescence

Flower



Pod



Seed



Root

AVRDC-07



Leaf (ventral side)

Leaf (dorsal side)

Inflorescence

Flower



Pod



Seed



Root

AVRDC-08

Fig. 14. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-09



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-10

Fig. 14. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-11



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-12

Fig. 14. Cont'd



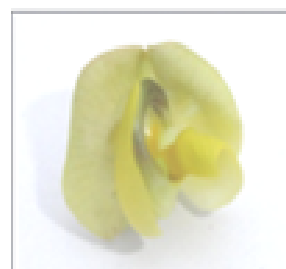
Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-13



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-14

Fig. 14. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Pod



Seed



Root

AVRDC-15



Pod



Seed



Root

MBM-390-94



Pod



Seed



Root

MBM-657

Fig. 14. Cont'd



Pod



Seed



Root

MBM-527-114



Pod



Seed



Root

MBM-573-69



Pod



Seed



Root

MBM-289-4



Pod



Seed



Root

MBM-656-51(2)

Fig. 14. Cont'd



Pod



Seed



Root

MBM-07 (seg)



Pod



Seed



Root

MBM-477-60



Pod



Seed



Root

MBM-427-87



Pod



Seed



Root

MBM-590-93

Fig. 14. Cont'd



MBM-508-67

Fig. 14. Cont'd

Molecular characterization of five mungbean germplasm using SSR markers

Out of 34, five different mungbean germplasm were analyzed as a group for SSR analysis and others were not genotyped because of time constraints. But the genotyping will be continued even after project completion. The five primers initially tested among them, two primers (MBSSR41 and MBSSR60) produced amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of SSR markers is shown in Fig. 15.

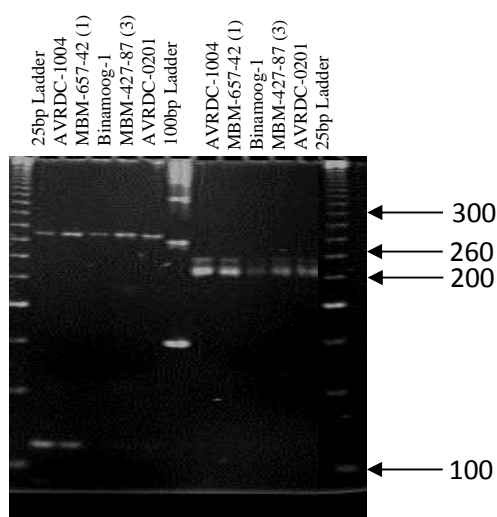


Fig. 15. Microsatellite profiles of 5 Mungbean germplasm at loci MBSSR41 & MBSSR60

Crop: Jute (*Chorchorus capsularis*)

Morphological Characterization of Jute varieties/germplasm

Three BINA released jute varieties and five germplasm were grown for morphological characterization at BINA Head Quarter farm, Mymensingh during Kharif-1 season, 2013. Plot size was 5m x 0.3 m. Each row was 5m long. Distances between rows and plants were 30 and 6-8 cm, respectively. Fertilizers and normal cultural practices were done to ensure normal growth and development of plant. Morphological characterization and identification of the traits of documentation for distinctness of the varieties/germplasm were recorded and photograph taken from the field using the approved descriptors of IBPGR and IPGRI and are presented in Table 12 & 13 and Fig. 16-17.

Table 12. Distinctness of the morphological characters of jute varieties

Sl. No.	State of the character	Atompat-38	Binadeshipat-2	Binadeshipatshak-1
1.	Stem colour	Green-no sign of any neck pigmentation (G)	Green-no sign of any neck pigmentation (G)	Green-no sign of any neck pigmentation (G)
2.	Petiole colour	Green (G)	Green (G)	Green (G)
3.	Stipule shape	Present, Leaf shaped	Present, Scaly	Present, Scaly
4.	Stipule colour	Green (G)	Green (G)	Green (G)
5.	Leaf shape	Ovate-Lanceolate	Ovate-Lanceolate	Ovate-Lanceolate
6.	Leaf texture	Rough or non-glossy (R)	Rough or non-glossy (R)	Rough or non-glossy (R)
7.	Leaf margin	Wavy (W)	Wavy (W)	Wavy (W)
8.	Pigmentation of flower seed (Calyx)	Green (G)	Green (G)	Green (G)
9.	Pigmentation of fruit	Green (G)	Green (G)	Green (G)
10.	Seed dispersal mechanism	Indehiscent	Indehiscent	Indehiscent
11.	Immature fruit colour	Dull green	Dull green	Dull green
12.	Seed coat colour	Black	Black	Black
13.	1000-seed weight (g)	3.6	3.4	3.2



Leaf (ventral side)

Leaf (dorsal side)

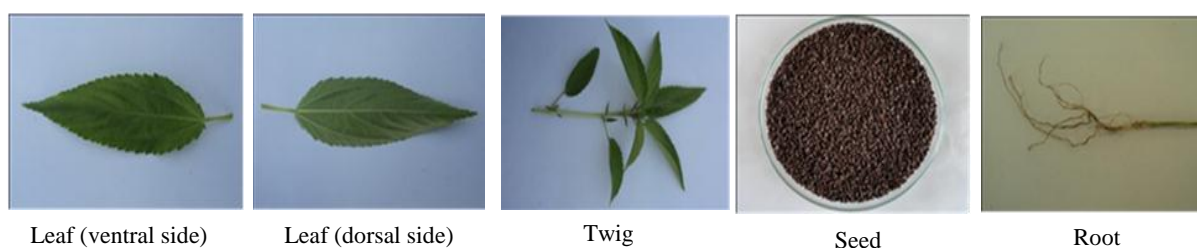
Twig

Seed

Root

Atompat-38

Fig. 16. Photograph showing different parts of jute varieties



Binadeshipat-2



Binapatshak-1

Fig. 16. Cont'd

Table 13. Distinctness of the morphological characters of jute germplasm

Sl. No.	State of the character	O-700-4	O-800-8	O-400-4	O-600-7	O-800-3
1.	Stem colour	Green	Green	Green	Green	Green
2.	Petiole colour	Green	Green	Green	Green	Green
3.	Stipule shape	Present, Scaly	Present, Scaly	Present, Scaly	Present, Scaly	Present, Scaly
4.	Stipule colour	Green	Green	Green	Green	Green
5.	Leaf shape	Ovate-Lanceolate	Ovate-Lanceolate	Ovate-Lanceolate	Ovate-Lanceolate	Ovate-Lanceolate
6.	Leaf texture	Rough	Rough	Glossy	Glossy	Rough
7.	Leaf margin	Non wavy	Non wavy	Wavy	Non wavy	Wavy
8.	Pigmentation of flower seed (Calyx)	Green	Light green	Green	Green	Green
9.	Pigmentation of fruit	Green	Green	Dull green	Green	Green
10.	Seed dispersal mechanism	Indehiscent	Indehiscent	Indehiscent	Indehiscent	Indehiscent
11.	Immature fruit colour	Green	Light green	Green	Green	Green
12.	Seed coat colour	Black	Black	Black	Dark ash	Black
13.	1000-seed weight (g)	3.2	3.5	3.4	3.6	3.2



Leaf (ventral side)

Leaf (dorsal side)

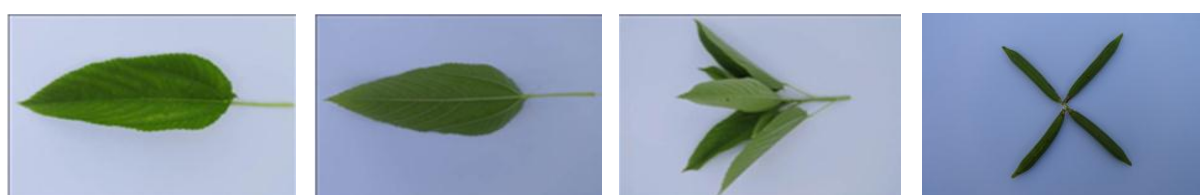
Twig



Seed

Root

700-4



Leaf (ventral side)

Leaf (dorsal side)

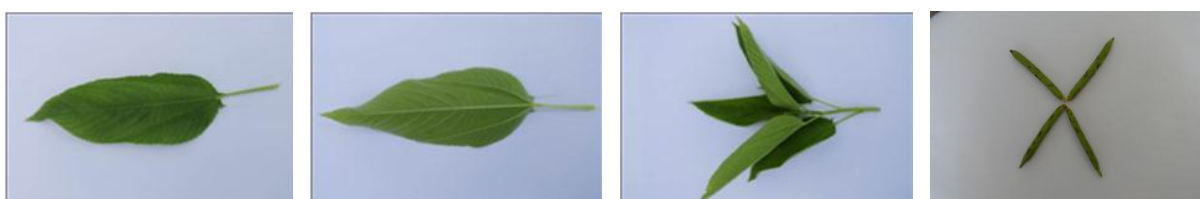
Twig



Seed

Root

800-8



Leaf (ventral side)

Leaf (dorsal side)

Twig



Seed

Root

400-4

Fig. 17. Photograph showing different parts of jute germplasm



Leaf (ventral side)



Leaf (dorsal side)



Twig



Seed



Root

600-7



Leaf (ventral side)



Leaf (dorsal side)



Twig



Seed



Root

800-3

Fig. 17 . Cont'd

Molecular characterization of five jute germplasm using RAPD markers

Out of 8, five different jute germplasm were analyzed as a group for RAPD analysis. The five primers initially tested among them, two primers (**OPA01** and **OPA02**) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of RAPD markers is shown in Fig. 18. Molecular analysis of rest of the germplasm was not done due to time constraint.

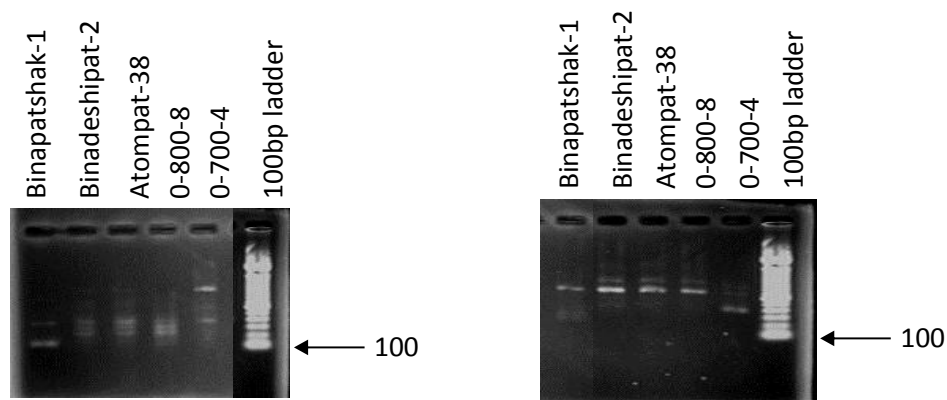


Fig. 18. RAPD profiles of 5 jute varieties/germplasm using OPA01and OPA2

Crop: Soybean (*Glycine max*)

Morphological Characterization of Soybean varieties/germplasm

Two released soybean varieties (Binasoybean-1 and Binasoybean-2) and 12 germplasm (out of 22) were put into experimental field at BINA Head Quarter farm, Mymensingh during Rabi season, 2012. The experiment was laid out in a randomized complete block design with three replications. Spacing between rows was 30 cm, and 5-7 cm between plants in a row. Unit plot size was (3m x 2m). Recommended production packages were followed to ensure normal plant growth and development. Morphological characterization and identification of the traits of documentation for distinctness of the varieties/germplasm were recorded and photograph taken from the field using the approved descriptors of IBPGR and IPGRI. Data recorded from the experiment are presented in Table 14 & 15 and Fig. 19 & 20. There is not much variation in soybean varieties. Molecular analysis was not done for soybean due to unavailability of primers.

Table 14. Distinctness of the morphological characters of soybean varieties

Sl. No.	State of the characters	Binasoybean-1	Binasoybean-2
1.	Stem determination	Determinate	Determinate
2.	Shattering score	No shattering	No shattering
3.	Plant height (cm)	48-57	42-55
4.	Number of primary branches/plant	2-3	3-4
5.	Number of pods/plant	46-52	45-55
6.	Seeds/pod	2-3	2-3
7.	Seed colour	Yellowish	Light yellowish
8.	Days to flowering	40-45	36-40
9.	Days to maturity	105-110	95-100
10.	100 -seed weight (g)	8.0-8.2	8.1-8.3
11.	Oil content (%)	19	18
12.	Protein (%)	44.5	43.0



Leaf (ventral side)



Leaf (dorsal side)



Fruit bearing habit



Fruit



Seed



Root

Binasoybean-1



Leaf (ventral side)



Leaf (dorsal side)



Fruit bearing habit



Fruit



Seed



Root

Binasoybean-2

Fig. 19. Photograph showing different parts of soybean varieties

Table 15. Distinctness of the morphological characters of soybean germplasm

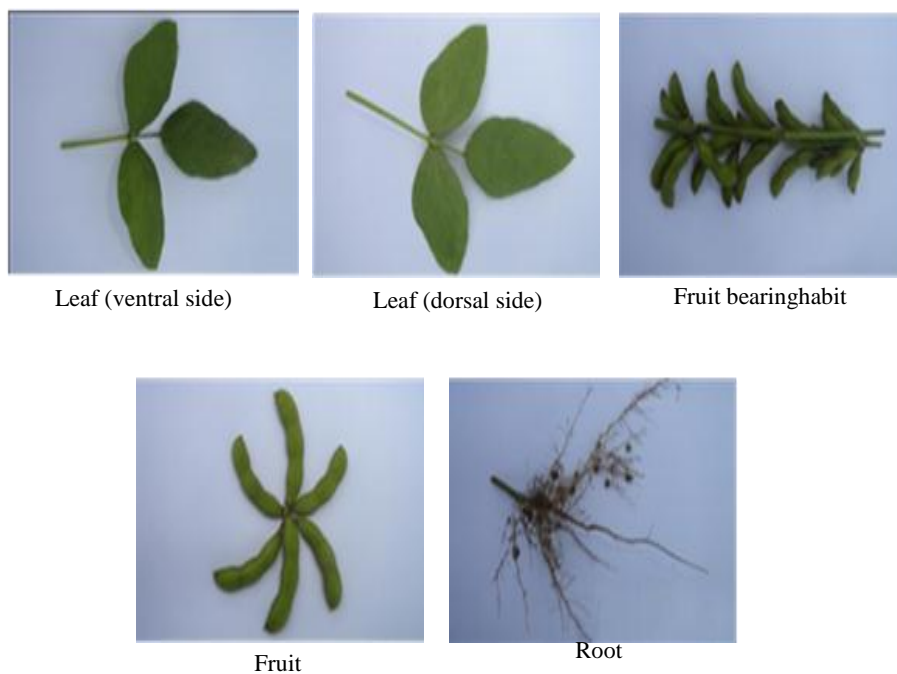
Sl. No.	State of the characters	AVRDC-73	AVRDC-78	SBM-12	SBM-17
1.	Stem determination	Determinate	Indeterminate	Determinate	Indeterminate
2.	Shattering score	Non-shattering	Non-shattering	Non-shattering	Non-shattering
3.	Plant height (cm)	34.4	36.5	41.3	39.8
4.	Number of primary branches/plant	3-4	2-3	4-5	3.4
5.	Number of pods/plant	60	56	47	52
6.	Pod length (cm)	2.5-3.0	2.0-2.5	1.8-2.5	1.9-2.3
7.	Seeds/pod	1.8	1.7	2.2	1.9
8.	Seed colour	White	Cream	Cream	White
9.	Days to flowering	50-55	45-50	56-60	40-45
10.	Days to maturity	119	115	126	120
11.	100 -seed weight (g)	14.3	12.5	13.6	11.6

Table 15. Cont'd

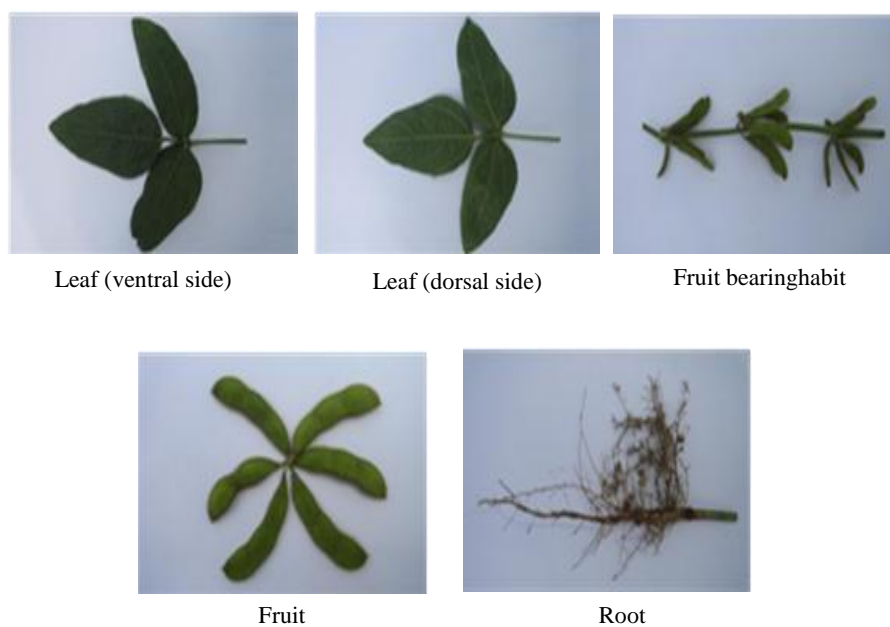
Sl. No.	State of the characters	SBM-20	SBM-23	BAU S-70	BAU S-73
1.	Stem determination:	Indeterminate	Determinate	Indeterminate	Indeterminate
2.	Shattering score	No shattering	No shattering	No shattering	No shattering
3.	Plant height (cm)	40.3	38.5	36.8	74.2
4.	Number of primary branches/plant	2-3	3-4	2-3	4-5
5.	Number of pods/plant	44	48	52	77
6.	Pod length (cm)	2.0-2.5	1.9-2.5	2.0-2.4	2.2-2.6
7.	Seeds/pod	1.8-2.0	1.9-2.3	1.6-2.1	1.7-2.0
8.	Seed colour	Cream	Cream	Cream	Cream
9.	Days to flowering	48-52	43-47	51-56	44-47
10.	Days to maturity	110	117	112	109
11.	100-seed weight (g)	13.0	12.6	12.2	14.0

Table 15. Cont'd

Sl. No.	State of the characters	SBM-15	SBM-9	SBM-18	SBM-22
1.	Stem determination	Indeterminate	Indeterminate	Indeterminate	Determinate
2.	Shattering score	No shattering	No shattering	No shattering	No shattering
3.	Plant height (cm)	52.2	43.6	56.0	48.2
4.	Number of primary branches/plant	3-4	3-5	4-5	4-5
5.	Number of pods/plant	62	57	49	53
6.	Pod length (cm)	2.3-2.6	2.0-2.5	2.0-2.4	2.0-2.5
7.	Seeds/pod	1.9-2.1	1.6-2.6	2.0-2.2	1.8-2.0
8.	Seed colour	Cream	Cream	Cream	Cream
9.	Days to flowering	40-45	40-45	44-47	46-50
10.	Days to maturity	110	108	112	114
11.	100 -seed weight (g)	12.0	11.0	14.0	14.0



AVRDC-73



AVRDC-78

Fig. 20. Photograph showing different parts of soybean germplasm



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

SBM-9



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

SBM-15

Fig. 20. Cont'd



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

SBM-17



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

SBM-18

Fig. 20. Cont'd



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

BAU S/70



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

BAU S/73

Fig. 20. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Fruit bearing habit



Fruit



Root

SBM-20



Leaf (ventral side)



Leaf (dorsal side)



Fruit bearing habit



Fruit



Root

SBM-22

Fig. 20. Cont'd



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

SBM-23



Leaf (ventral side)

Leaf (dorsal side)

Fruit bearing habit



Fruit



Root

SBM-12

Fig. 20. Cont'd

Molecular characterization of six soybean germplasm using RAPD markers

Out of 18, six different soybean germplasm were characterized using RAPD markers. The four primers initially tested among them, one primers (**OPB10**) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of RAPD markers is shown in Fig. 21. Molecular analysis of rest of the germplasm was not done due to time constraint.

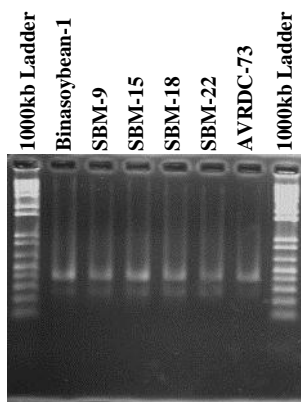


Fig. 21. RAPD profiles of 6 soybean varieties/germplasm using OPB-10

Crop: Chickpea (*Cicer arietinum*)

Morphological Characteristic of Chickpea varieties/germplasm

A total of 10 chickpea genotypes along with six released varieties were grown in farmer's field at Godagari, Rajshahi during Rabi season, 2011-12. The main objective of the study was to identify the traits of distinctness of the variety/germplasm and documented the characters. The experiment was conducted in randomized complete block design with three replications. Unit plot size was 5m x 0.8 m. Row to row and plant to plant distances were 40 and 15 cm, respectively. Morphological characterization and identification of the traits of documentation for distinctness of the varieties/germplasm were recorded and photograph taken from the field using the approved descriptors of IBPGR and IPGRI and are presented in Table 16 & 17 and Fig. 22 & 23. The variety Hyprosola possess small seed size and others are bold seeded. Green seed and seed coat colour is found in Binasola-5.

Table 16. Distinctness of the morphological characters of chickpea varieties

Plant characteristics	Hyprosola	Binasola-2	Binasola-3	Binasola-4	Binasola-5	Binasola-6
Plant pigmentation	Low anthocyanin, stems and leaves partly light purple	No anthocyanin, stems and leaves green	No anthocyanin, stems and leaves green	Highly purple	Low anthocyanin, stems and leaves partly light purple	Low anthocyanin, stems and leaves partly light purple
Plant hairiness	Lightly pubescent	Lightly pubescent	Lightly pubescent	Lightly pubescent	Lightly pubescent	Lightly pubescent
Leaf type	Multipinnate	Multipinnate	Multipinnate	Multipinnate	Multipinnate	Multipinnate
Number of leaflets/leaf	11-13	11-13	11-13	11-13	11-13	11-13

Table 16. Contd.

Plant characteristics	Hyprosola	Binasola-2	Binasola-3	Binasola-4	Binasola-5	Binasola-6
Days to 50% flowering	50-55	45-50	40-45	45-50	45-50	45-50
Days to maturity	135-140	120-130	115-120	120-125	120-125	122-126
Number of seeds/pod	1-2	1-2	1-2	1-2	1-2	1-2
Flower colour	Pink	Pink	Light pink	Light blue	Light blue	Light pink
Number of flowers and pods/peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle
Pod length (mm)	Short (<15 mm)	Medium (15-20mm)	Short (<15 mm)	Medium (15-20mm)	Short (<15 mm)	Short (<15 mm)
Pod dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence
Number of pods/plant	52	40	35	35	40	35
Seed shape	Angular, ram`s head	Angular, ram`s head	Angular, ram`s head	Angular, ram`s head	Angular, ram`s head	Angular, ram`s head
Testa texture	Rough	Smooth	Rough	Rough	Rough	Smooth
Seed colour	Light brown	Light brown	Light brown	Light yellow	Green	Dark brown
Absence/presence of minute black dots	Absence	Absence	Absence	Absence	Absence	Absence
100-seed weight (g)	9.57	21.57	15.58	13.12	10.21	13.69
Growth habit	Semi-erect (16-25 ⁰ from vertical)	Erect (0-15 ⁰ from vertical)	Semi-erect (16-25 ⁰ from vertical)	Semi-erect (16-25 ⁰ from vertical)	Semi-erect (16-25 ⁰ from vertical)	Semi-erect (16-25 ⁰ from vertical)
Leaflet size (mm)	small (<10mm long, ,4 mm wide)	Medium (10-15mm long ,4-12 mm wide)	small (<10mm long, ,4 mm wide)	Medium (10-15mm long ,4-12 mm wide)	Medium (10-15mm long ,4-12 mm wide)	Medium (10-15mm long ,4-12 mm wide)
Leaf area (cm ²)	Small (<12)	Medium (13-16)	Small (<12)	Medium (13-16)	Medium (13-16)	Medium (13-16)
Number of branches/plant	5-8	4-5	4-6	4-6	5-6	4-6
Plant canopy height (cm)	33-40	45-50	46-49	38-42	35-40	35-40
Plant canopy width (cm)	55-60	40-45	40-45	40-45	55-60	40-45
Seed yield (t/ha)	1.5	1.6	1.6	1.6	1.5	1.7



Plant



Pod



Seed

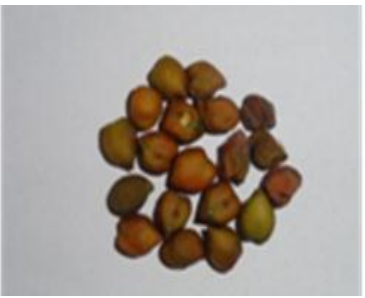
Hyprosola



Plant



Pod



Seed

Binasola-2



Plant



Pod



Seed

Binasola-3

Fig. 22. Photograph showing different parts of chickpea varieties



Plant



Pod



Seed

Binasola-4



Plant



Pod



Seed

Binasola-5



Plant



Pod



Seed

Binasola-6

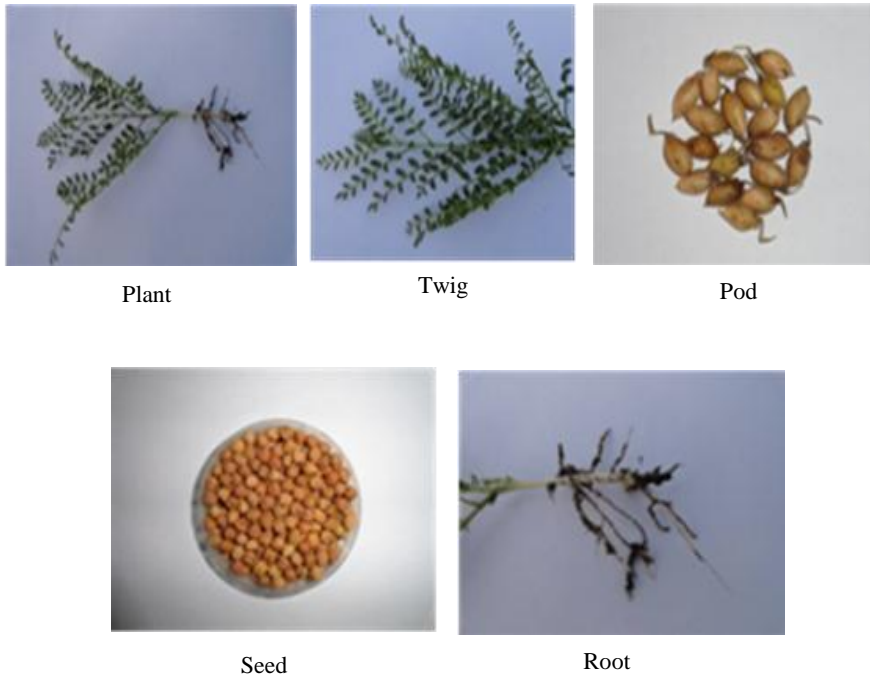
Fig. 22. Cont'd

Table 17. Distinctness of the morphological characters of chickpea germplasm

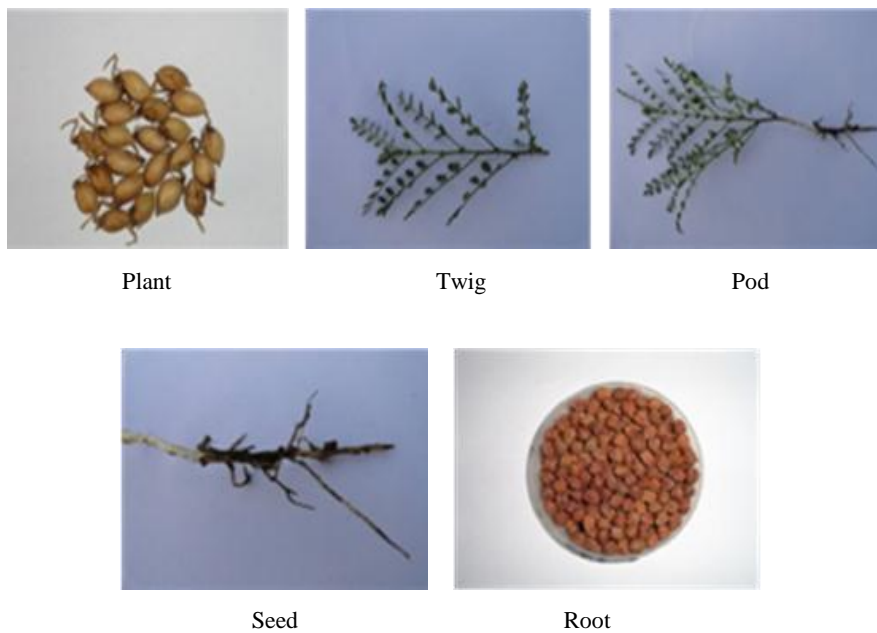
Plant characteristics	CPM-860	P-70	CPM-kab-400	CPM-860-200	CPM-BAR-7-400
Plant pigmentation	No anthocyanin, stems and leaves green	No anthocyanin, stems and leaves green	No anthocyanin, stems and leaves green	No anthocyanin, stems and leaves green	No anthocyanin, stems and leaves green
Plant hairiness	Lightly pubescent	Lightly pubescent	Lightly pubescent	Lightly pubescent	Lightly pubescent
Leaf type	Multipinnate	Multipinnate	Multipinnate	Multipinnate	Multipinnate
Number of leaflets/leaf	11-13	11-13	11-13	11-13	11-13
Days to 50% flowering	50-55	55-60	55-58	50-55	45-50
Days to maturity	120-125	125-130	110-115	115-120	105-110
Number of seeds/pod	1-2	1-2	1-2	1-2	1-2
Flower colour	Pink	Pink	Light pink	Light pink	pink
Number of flowers and pods/peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle
Pod length (mm)	Medium (15-20mm)	Medium (15-20mm)	Medium (15-20mm)	Short (<15 mm)	Medium (15-20mm)
Pod dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence
Number of pods/plant	45	40	42	39	48
Seed shape	Angular, ram's head	Angular, ram's head	Angular, ram's head	Angular, ram's head	Angular, ram's head
Testa texture	Smooth	Smooth	Smooth	Smooth	Rough
Seed colour	Light brown	Light brown	white	Light brown	Light brown
Absence/presence of minute black dots	Absence	Absence	Absence	Absence	Absence
100-seed weight (g)	23.2	23.9	23.63	24.75	14.65
Growth habit	Erect (0-15° from vertical)	Erect (0-15° from vertical)	Semi-erect (16-25° from vertical)	Semi-erect (16-25° from vertical)	Semi-erect (16-25° from vertical)
Leaflet size (mm)	Medium (10-15mm long, 4-12 mm wide)	Medium (10-15mm long, 4-12 mm wide)	Medium (10-15mm long, 4-12mm wide)	Medium (10-15mm long, 4-12mm wide)	small (<10mm long, 4 mm wide)
Leaf area (cm ²)	Medium (13-16)	Medium (13-16)	Medium (13-16 cm ²)	Medium (13-16 cm ²)	Small (<12 cm ²)
Number of branches/plant	4-5	4-5	4-6	4-6	5-6
Plant canopy height (cm)	45-50	40-45	45-50	36-39	43-46
Plant canopy width (cm)	40-45	40-45	56-60	55-60	55-60
Seed yield (t/ha)	1.7	1.8	2.0	1.7	1.5

Table 17. Cont'd

Plant characteristics	CPM-BAR-4-300	CPM-860-300	CPM-860-400	CPM-BAR-4-400	CPM-BAR-7-300
Plant pigmentation	Low anthocyanin, stems and leaves green	Low anthocyanin, stems and leaves partly light purple	No anthocyanin, stems and leaves green	No anthocyanin, stems and leaves green	No anthocyanin, stems and leaves green
Plant hairiness	Lightly pubescent	Lightly pubescent	Lightly pubescent	Lightly pubescent	Lightly pubescent
Leaf type	Multipinnate	Multipinnate	Multipinnate	Multipinnate	Multipinnate
Number of leaflets/leaf	11-13	11-13	11-13	11-13	11-13
Days to 50% flowering	43-47	40-45	44-50	43-47	52-55
Days to maturity	115-120	120-125	120-125	115-120	120-125
Number of seeds/pod	1-2	1-2	1-2	1-2	1-2
Flower colour	Light blue	Light blue	Pink	Light pink	pink
Number of flowers and pods/peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle	Single pod per peduncle
Pod length (mm)	Short (<15 mm)	Short (<15 mm)	Short (<15 mm)	Medium (15-20mm)	Medium (15-20mm)
Pod dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence	>10% dehiscence
Number of pods/plant	47	50	43	48	35
Seed shape	Angular, ram`s head	Angular, ram`s head	Angular, ram`s head	Angular, ram`s head	Angular, ram`s head
Testa texture	Rough	Smooth	Smooth	Rough	Rough
Seed colour	Light brown	Dark brown	Dark brown	Light brown	Light brown
Absence/presence of minute black dots	Absence	Absence	Absence	Absence	Absence
100-seed weight (g)	13.58	22.23	21.86	13.55	14.66
Growth habit	Erect (0-15° from vertical)	Semi-erect (16-25° from vertical)	Semi-erect (16-25° from vertical)	Semi-erect (16-25° from vertical)	Erect (0-15° from vertical)
Leaflet size (mm)	small (<10mm long, 4 mm wide)	Medium (10-15mm long, 4-12 mm wide)	Medium (10-15mm long, 4-12 mm wide)	small (<10mm long, 4 mm wide)	small (<10mm long, 4 mm wide)
Leaf area (cm ²)	Small (<12 cm ²)	Medium (13-16 cm ²)	Medium (13-16 cm ²)	Small (<12 cm ²)	Small (<12 cm ²)
Number of branches/plant	5-6	4-6	5-6	4-6	4-6
Plant canopy height (cm)	33-38	36-40	34-40	33-36	37-42
Plant canopy width (cm)	42-46	50-55	45-50	45-50	45-50
Grain yield (t/ha)	1.5	1.7	1.6	1.4	1.5



CPM-860



P-70

Fig. 23. Photograph showing different parts of chickpea germplasm



Plant



Pod



Seed

CPM-860-200



Plant



Pod



Seed

CPM-860-300



Plant



Pod



Seed

CPM-860-400



Plant



Pod



Seed

CPM-BAR-4-300

Fig. 23. Cont'd



Plant



Pod



Seed

CPM-BAR-4-400



Plant



Pod



Seed

CPM-BAR-7-300



Plant



Pod



Seed

CPM-BAR-7-400



Plant



Pod



Seed

CPM-kab-400

Fig. 23. Cont'd

Molecular Characterization of Chickpea varieties using RAPD markers

Primer selection and RAPD profiles

Four chickpea varieties were studied using RAPD technique to characterize genetic variation within and between the genotypes, as well as their relationship. It has been reported by many authors that RAPD can be studied as efficient tool for genetic characterization of chickpea genotypes (Iruela *et al.*, 2002; Sudupak *et al.*, 2002).

Eleven primers initially tested among four chickpea varieties (out of 16 genotypes), three primers (OPA02, OPC02 and 67AB10G7) yielded comparatively maximum number of amplification products with high intensity and minimal smearing, good resolution and also clear bands. Amplified fragments number per primer varied. The selected three primers produced 18 distinct bands. Among the three primers OPA02 and OPC02 generated maximum number of bands (8) and (7), respectively and other primer 67AB10G7 produced three scorable bands. Rest of the germplasm was not tested for molecular characterization due to lack of primers.

Eighteen distinct bands were produced by the three primers of which 16 were considered as polymorphic. Among the three primers OPA02 and OPC02 generated maximum number of polymorphic bands (7) that signified a high level of polymorphism and other primer 67AB10G7 produced two polymorphic bands. Average polymorphism across the primers was found 84.72% with the highest of 100% (OPC02) and the lowest of 66.66% (67AB10G7). The present experiment produced six scorable bands per primer and 5.33 polymorphic bands per primer (Table 18). This is almost same as of polymorphism detected by the arbitrary primers compared to the previous reports on other RAPD studies of chickpea genotypes. Such as five polymorphic bands per primer in chickpea accessions (Banerjee *et al.*, 1999) and 5.52 polymorphic bands per primer in Indian *Cicer* species (Kumar *et al.*, 2004). The reasons of the considerable number of average scorable and polymorphic bands could be that the primers used in this study, consist of 60-70% GC content. The level of polymorphism (84.72%) indicated the effectiveness of RAPD technique to study polymorphism or diversity among chickpea genotypes.

Table 18. Number and percentage of polymorphic bands across the primers in studied chickpea germplasm

Primer codes	Total number of band scored	Polymorphic bands	Polymorphism (%)	Mean polymorphism
OPA02	8	7	87.5	84.72%
OPC02	7	7	100	
67AB10G7	3	2	66.66	
Total	18	16		
Average	6	5.33		

The RAPD band profiles of different three primers are shown in Fig. 24-26.

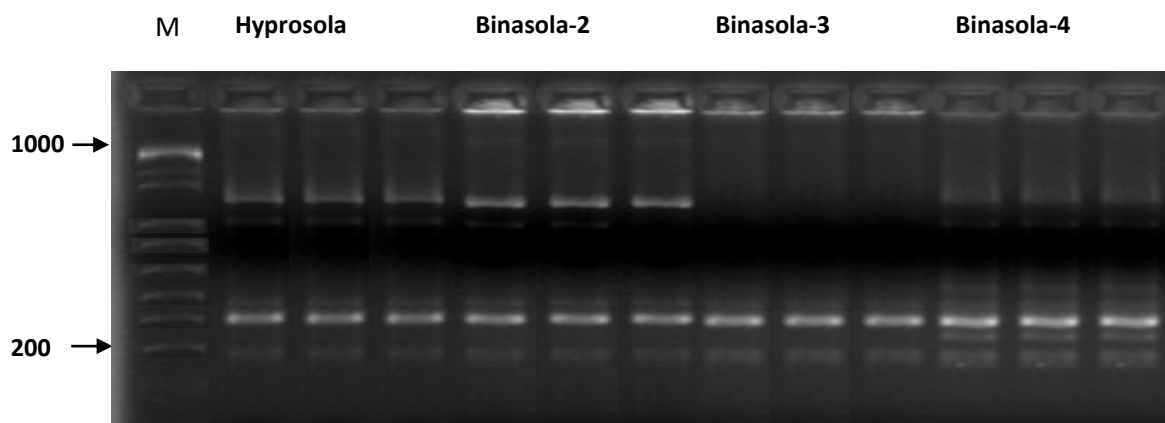


Fig. 24. RAPD gel profile with fragments generated by OPC02 in four germplasms of chickpea: Hyprosola, Binasola-2, Binasola-3 and Binasola-4 accessions; M: Molecular weight marker 1Kb⁺ DNA ladder

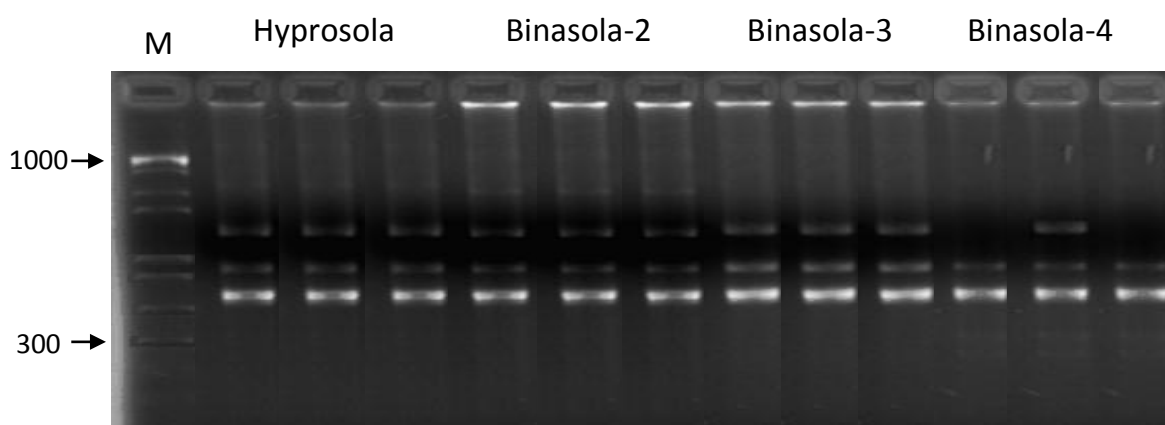


Fig. 25. RAPD gel profile with fragments generated by 67AB10G7 in four germplasms of chickpea. Hyprosola, Binasola-2, Binasola-3 and Binasola-4 accessions; M: Molecular weight marker 1Kb⁺ DNA ladder

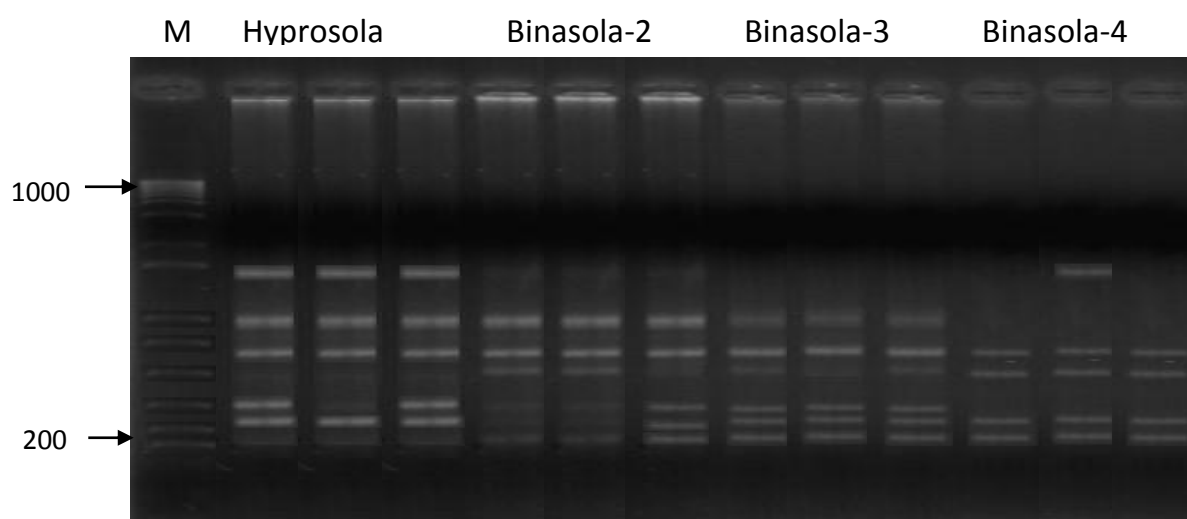


Fig. 26. RAPD gel profile with fragments generated by OPA02 in four germplasms of chickpea. Hyprosola, Binasola-2, Binasola-3 and Binasola-4 accessions; M: Molecular weight marker 1 Kb⁺ DNA ladder

Molecular characterization of three chickpea varieties using SSR marker

Three chickpea varieties were characterized using SSR marker. The six primers initially tested among them, one primer (GA2) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of SSR marker is shown in Fig. 27. Molecular analysis of rest of the germplasm was not done due to time constraint.

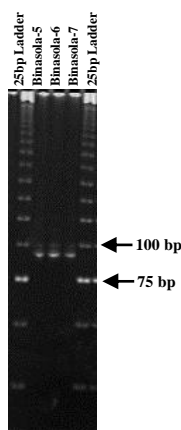


Fig. 27. RAPD profiles of Binasola-5, Binasola-6 and Binasola-7 using SSR marker (GA-2)

Crop: Mustard (*Brassica* sp.)

Morphological Characterization of Mustard varieties/germplasm

The experiment was carried out at the BINA Head Quarter farm, Mymensingh. Eight mustard varieties and 9 germplasm (out of 15) were grown for morphological and molecular characterization. The experiment was laid out in a randomized complete block design with three replications. Seeds were sown during November 2012. Row to row spacing was 30 cm while plant to plant distance was 6-8 cm within rows. Unit plot size was 3m × 2m. Recommended management practices were followed for normal plant growth and development. Data on all the traits in the descriptor (IBPGR/IPGRI) were recorded and photograph taken from the field and presented in Table 19 & 20 and Fig. 28 & 29. Glabrous to very sparse are observed in mustard varieties and no other distinct variations was not observed among the tested germplasm.

Table 19. Distinctness of the morphological characters of mustard varieties

Characters	Safal	Agrani	Bina sharisha-3	Bina sharisha-4	Bina sharisha-5	Bina sharisha-6	Bina sharisha-7	Bina sharisha-8
Seedling: Hypocotyl colour	Purple	Purple	Purple	Purple	Purple	Purple	Purple	Purple
Leaf colour	Green	Green	Light green	Light green	Light green	Dark green	Dark green	Dark green
Leaf marginal incision	Serrate	Serrate	Serrate	Serrate	Serrate	Serrate	Serrate	Serrate
Seedling pubescence	Very sparse	Very sparse	Glabrous	Glabrous	Glabrous	Intermediate	Intermediate	Intermediate
Leaf blade shape	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Petiole and or midvein enlargement	Intermediate	Enlarged	Intermediate	Intermediate	Intermediate	Enlarged	Intermediate	Intermediate
Plant growth habit	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex
Floral apex	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots
Flowering head size	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Days to 1 st flowering	35-40	35-40	34-38	30-35	33-35	35-40	38-42	38-42
Root shape	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root
Days to maturity	90-95	85-90	85-90	80-85	85-90	90-95	98-102	92-98
Branching habit	Very elongated	Very elongated	Enlarged	Enlarged	Enlarged	Very elongated	Very elongated	Very elongated
Arrangement of siliqua	Erect	Erect	Erect	Erect	Spready	Erect	Erect	Erect
Seed/siliqua	Intermediate	Intermediate	Many	Many	Many	Intermediate	Intermediate	Intermediate
1000 seed weight (g)	3.5	3.5	3.4	3.4	3.3	3.0	3.4	3.5
Seed size and shape	Slightly flattened	Slightly flattened	Slightly flattened	Slightly flattened	Slightly flattened	Slightly flattened	Rounded	Rounded
Seed yield/plant (g)	2.4	2.3	2.4	2.6	2.4	2.3	2.5	2.4



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Stem



Fruit bearing
Stem Green



Green siliqua



Fruit bearing
Stem (Ripen)



Siliqua



Seed



Root

Safal



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Stem



Fruit bearing
Stem Green



Green siliqua



Fruit bearing
Stem (Ripen)



Siliqua



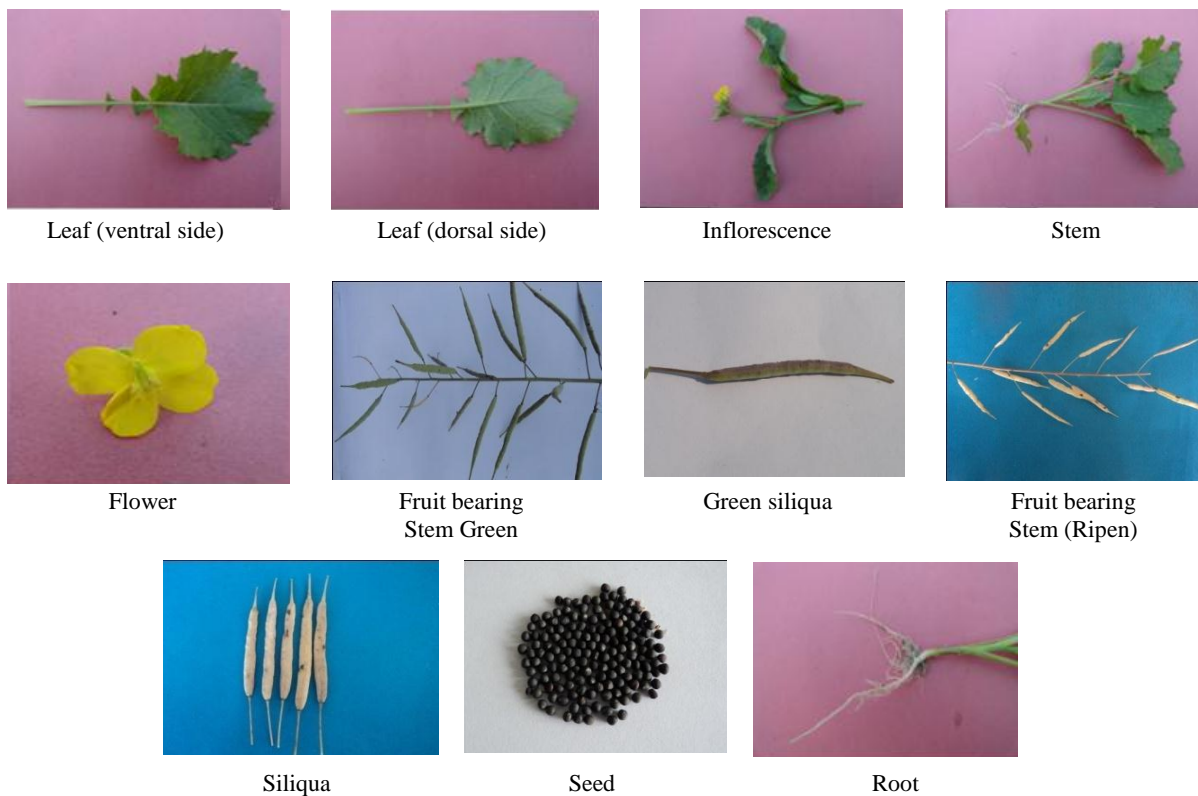
Seed



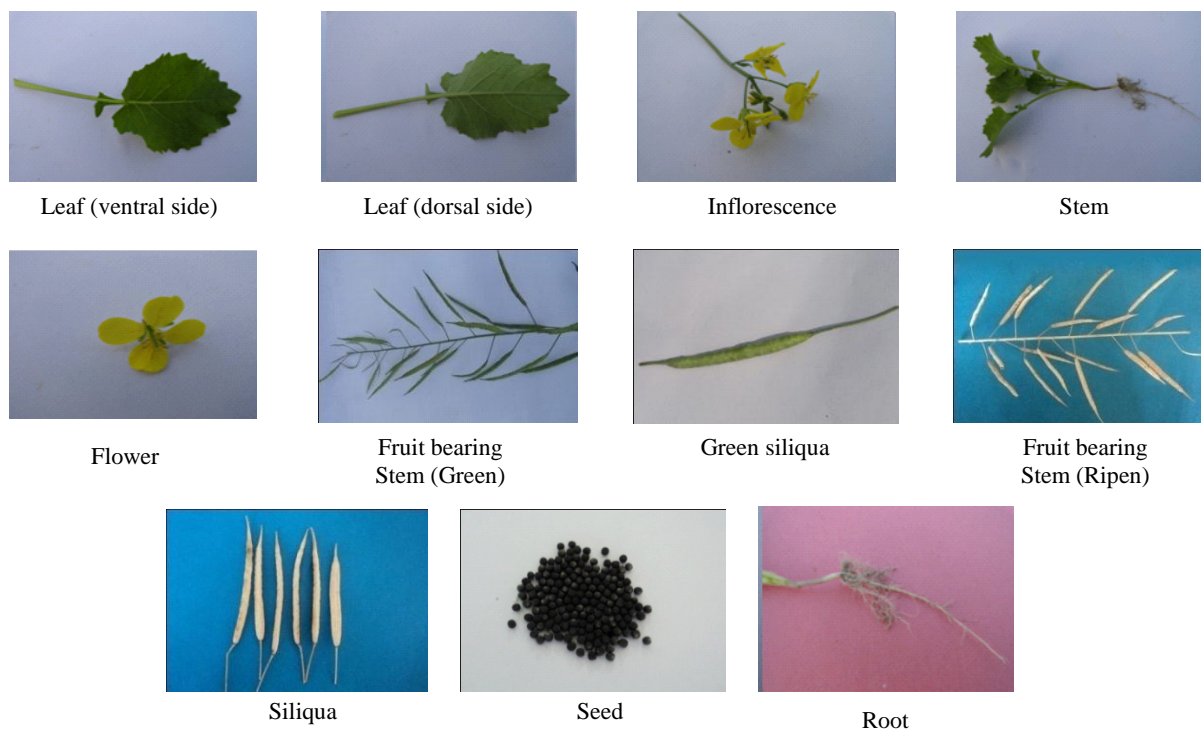
Root

Agroni

Fig. 28. Photograph showing different parts of mustard varieties



Binasharisa-3



Binasharisa-4

Fig. 28. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Stem



Flower



Fruit bearing
Stem Green



Green siliqua



Fruit bearing
Stem (Ripen)



Siliqua



Seed



Root

Binasharisa-5



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Stem



Fruit bearing
Stem Green



Green siliqua



Fruit bearing
Stem (Ripen)



Siliqua



Seed



Root

Binasharisa-6

Fig. 28. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Stem



Flower



Fruit bearing
Stem Green



Green siliqua



Fruit bearing
Stem Ripen



siliqua



Seed



Root

Binasharisa-7



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Stem



Green siliqua



Fruit bearing
Stem Green



Fruit bearing
Stem (Ripen)



Siliqua



Seed



Root

Binasharisa-8

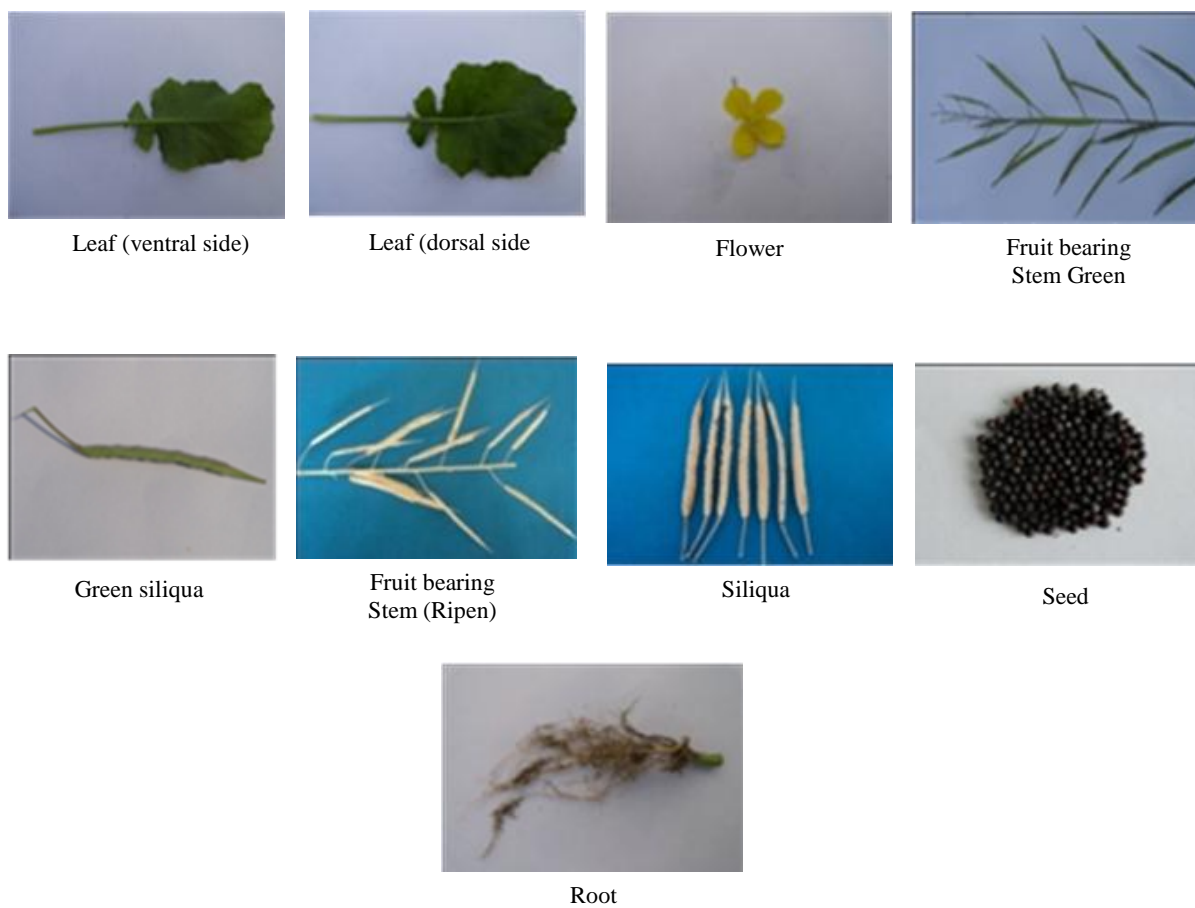
Fig. 28. Cont'd

Table 20. Distinctness of the morphological characters of mustard germplasm

Characters	MM-15	MM-51	MM-63	MM-64	RC-4	RC-5	RC-8	RC-9	RC-10
Hypocotyl colour	Purple	Purple	Purple	Purple	Purple	Pale green	Purple	Purple	Purple
Leaf colour	Light green	Light green	Light green	Light green	Light green	Light green	Light green	Light green	Light green
Leaf marginal incision	Serrate	Serrate	Serrate	Serrate	Serrate	Serrate	Serrate	Serrate	Serrate
Seedling pubescence	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous
Leaf blade shape	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Petiole and or midvein enlargement	Intermediate	Enlarged	Intermediate	Enlarged	Enlarged	Enlarged	Enlarged	Enlarged	Enlarged
Plant growth habit	Elongate non-branching stem supporting enlarged compact axillary buds	Elongate non-branching stem supporting enlarged compact axillary buds	Elongate non-branching stem supporting enlarged compact axillary buds	Elongate non-branching stem supporting enlarged compact axillary buds	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex	Elongate non-branching stem terminating in enlarged flora or pre-floral apex
Floral apex	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots	Enlarged stem with terminally branched raceme	Enlarged stem with terminally branched raceme	Terminal head with smaller heads on axillary shoots	Terminal head with smaller heads on axillary shoots
Flowering head size	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Days to 1 st flowering	30-31	28-30	30-32	30-32	28-30	28-30	28-30	28-30	28-30
Root shape	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root	Non swollen tap root
Days to maturing	80-82	78-80	80-82	83-85	80-82	73-75	78-80	80-82	80-82
Branching habit	Enlarged	Very elongated	Enlarged	Very elongated	Enlarged	Very elongated	Enlarged	Very elongated	Enlarged
Arrangement of siliqua	Erect	Spready	Erect	Erect	Spready	Erect	Erect	Spready	Erect
Seed/siliqua	Many	Intermediate	Many	Intermediate	Many	Intermediate	Many	Intermediate	Many
1000 seed weight (g)	3.2	3.4	3.4	3.5	3.3	3.1	3.3	3.4	3.2
Seed size and shape	Slightly flattened	Rounded	Slightly flattened	Slightly flattened	Rounded	Slightly flattened	Rounded	Rounded	Rounded
Seed yield/plant (g)	2.5	2.4	2.5	2.5	2.3	2.4	2.5	2.5	2.5



MM-15

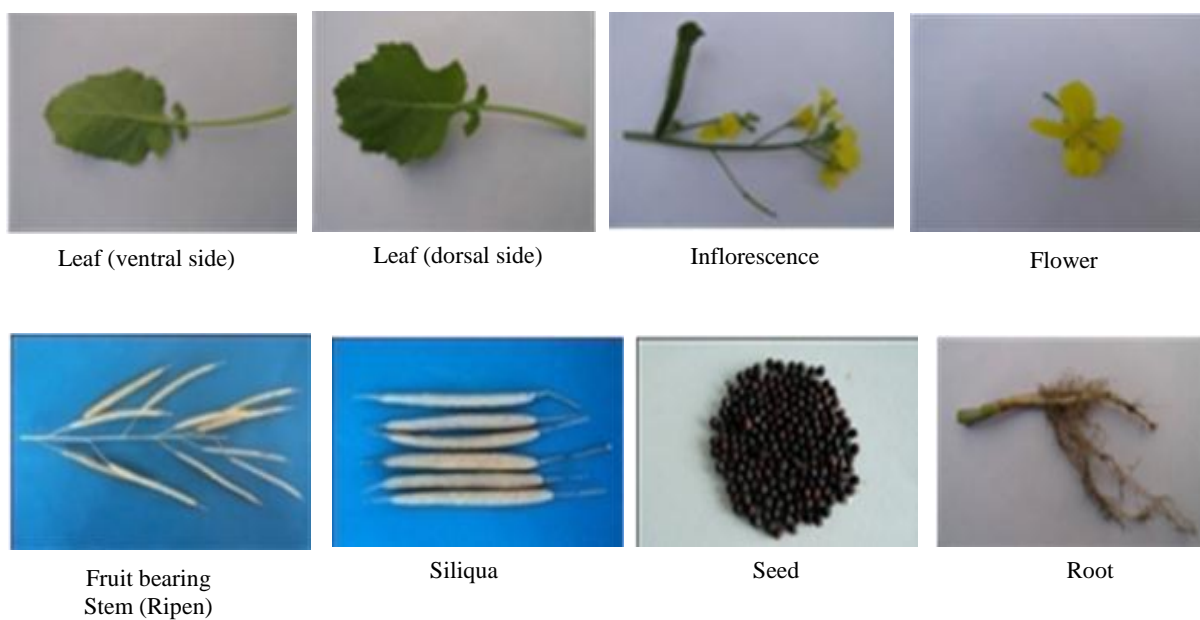


MM-63

Fig. 29. Photograph showing different parts of mustard germplasm



MM-51



MM-64

Fig. 29. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit bearing
Stem Green



Green siliqua



Seed



Root

RC-4



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit bearing
Stem Green



Green siliqua



Seed



Root

RC-5

Fig. 29. Cont'd



Leaf (ventral side)

Leaf (dorsal side)

Inflorescence

Flower



Fruit bearing
Stem Green

Green siliqua

Seed

Root

RC-8



Leaf (ventral side)

Leaf (dorsal side)

Inflorescence

Flower



Fruit bearing
Stem Green

Green siliqua

Seed

Root

RC-9

Fig. 29. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



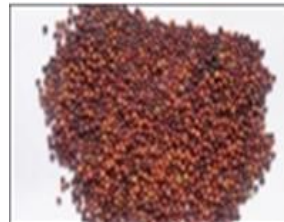
Flower



Fruit bearing
Stem Green



Green siliqua



Seed



Root

RC-10

Fig. 29. Cont'd

Molecular Characterization of Mustard varieties using RAPD markers

Primer selection and RAPD profile

Six different *Brassica* varieties including Safal, Agrani and Binasharisha-6 of *Brassica campestris*, Binasharisha-3, Binasharisha-4 and Binasharisha-5 of *B. napus* (out of 8 varieties) were analyzed as a group for RAPD analysis. The twelve primers initially tested among them, three primers (OPA02, OPB01 and OPC02) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. The three primers generated 22 distinct bands, 16 bands (72.73%) were considered as polymorphic and 6 bands (27.27%) have been taken as monomorphic bands (Table 21). The three primers, the highest number of bands (8) produced by OPA02 primer. Thus it showed a higher level of polymorphism and the other two primers OPB01 and OPC02 generated 7 bands of each. Besides this, the primer OPA02 amplified maximum number of polymorphic bands (6) and on the other hand, OPB01 and OPC02 both produced (5) polymorphic bands (Table 21). The polymorphic amplification bands ranged from 5-6 and were amounted to be 5.33 on an average.

Table 21. Total scorable bands and polymorphic bands amplified by three RAPD primers in *Brassica* spp. varieties

Primer Codes	Sequences (5-3)	Total number of bands scored	Size range (bp)	Number of polymorphic bands	Polymorphic Loci (%)
OPA02	TGCCGAGCTG	8	180>1000	6	72.73
OPB01	GTTTCGCTCC	7	150->1000	5	
OPC02	GTGAGGCGTC	7	150>1000	5	
Total		22		16	
Average		7.33		5.33	

The level of polymorphism (72.73%) indicated the effectiveness of RAPD technique to study substantial amount of polymorphisms or diversity among the different cultivars of *Brassica* spp. This proportion of polymorphism is higher compared to some previous RAPD analysis in *Brassica*, e.g. 98.03% among nine cultivars of *Brassica campestris*, *Brassica napus* and *Brassica juncea* (Saha, 2006) and 81.72% in Chinese mustard crops accessions (Fu *et al.*, 2006). This difference can be attributed to the primers used and the genotypes evaluated. On an average, the present experiment produced 7.33 scorable bands per primer and about 5.33 polymorphic RAPD markers per primer. This level of polymorphism detected by the arbitrary primers was almost similar to the previous reports in other RAPD studies on *Brassica* cultivars, such as 8.33 scored per primer in *Brassica napus*, *Brassica juncea* and introgressed material *Brassica napojuncea* (Karim, 2007).

Polymorphic loci and gene diversity

The number and proportion of polymorphic loci was found to be highest in Binasharisha-6 cultivar which were 14 and 63.63%, respectively (Table 22). The highest value of Nei's (1973) gene diversity (0.1024) and Shannon's information index (0.1455) were also observed in Agrani. On the other hand, the lowest proportion of polymorphic loci was observed in Binasharisha-4 is 40.91%, gene diversity and Shannon's information index estimated for the cultivars Safal, Binasharisha-3 and Binasharisha-4 which were 0.0272 and 0.0433, respectively (Table 22). Banding pattern of RAPD profiles are shown in Fig. 30-32.

Table 22. Estimation of genetic variation: number and proportion of polymorphic loci, Nei's gene diversity (h) and Shannon's information index (I) obtained in different *Brassica* spp. varieties

Sl. No.	Cultivar	Number of polymorphic loci	Proportion of polymorphic loci (%)	Gene diversity	Shannon's information index (I)
1.	Safal	11	50.00	0.0272	0.0433
2.	Agrani	10	45.45	0.1024	0.1455
3.	Binasharisha-3	11	50.00	0.0272	0.0433
4.	Binasharisha-4	9	40.91	0.0272	0.0433
5.	Binasharisha-5	10	45.45	0.0358	0.0526
6.	Binasharisha-6	14	63.63	0.0358	0.0526

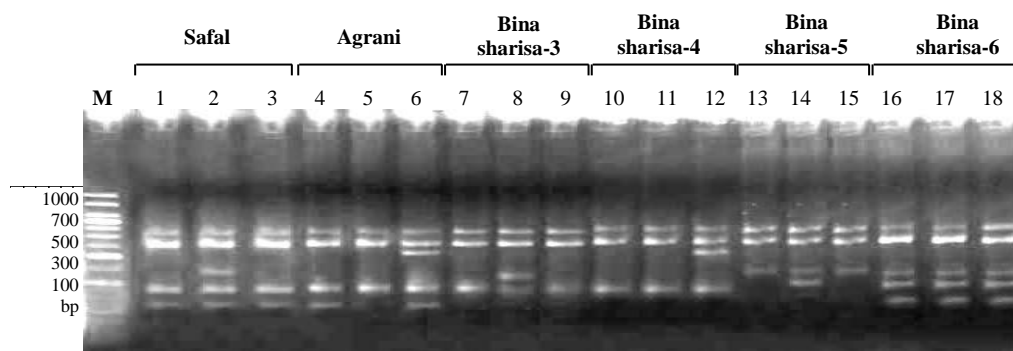


Fig. 30. RAPD profiles of six different varieties of *Brassica* spp. using OPA-02 primer

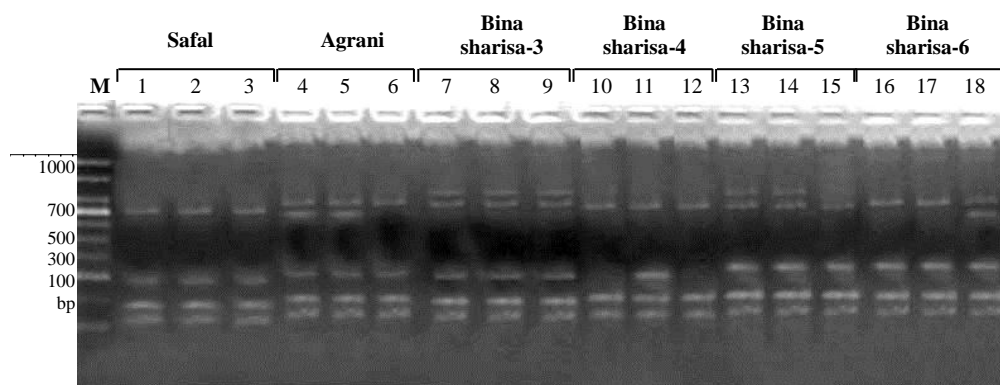


Fig. 31. RAPD profiles of six different varieties of *Brassica* spp. using OPB-01 primer

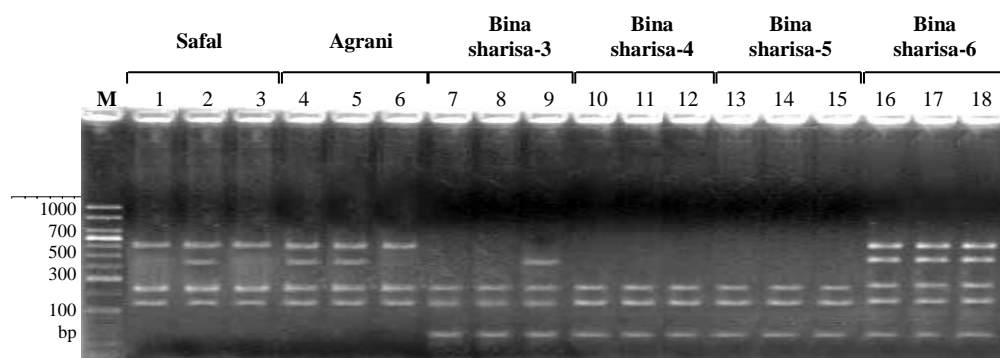


Fig. 32. RAPD profiles of six different varieties of *Brassica* spp. using OPC-02 primer

Genetic distance

The Nei's original measures of genetic distance (Nei, 1972) were calculated from combined data sets for three primers ranging from 0.1082 to 0.6635 (Table 23). The GD-value between the Safal and Binasharisa-6 cultivars was found to be the highest (0.6635) with the lowest genetic identity (0.5150) among the other pair-wise germplasms. The genetic distance between the Safal and Agrani cultivars pair was the lowest (0.1082) with the highest genetic identity (0.8975). The high genetic similarity supports the theory that they share a common origin (Xunjia *et al.*, 2000).

Table 23. Summary of Nei's (1972) genetic distance (below diagonal) and genetic identity (above diagonal) values between six *Brassica* varieties

Cultivar	Safal	Agrani	Bina sharisha-3	Bina sharisha-4	Bina sharisha-5	Bina sharisha-6
Safal	****	0.8975	0.7165	0.7305	0.5817	0.5150
Agrani	0.1082	****	0.8152	0.8288	0.6530	0.5966
Binasharisha-3	0.3334	0.2043	****	0.9174	0.7950	0.5917
Binasharisha-4	0.3140	0.1878	0.0862	****	0.8461	0.6511
Binasharisha-5	0.5418	0.4262	0.2294	0.1671	****	0.8014
Binasharisha-6	0.6635	0.5165	0.5248	0.4291	0.2214	****

UPGMA dendrogram

The unweighted pair group method of arithmetic means (UPGMA) dendrogram based on Nei's (1972) original measures of genetic distance (GD) was constructed (Fig. 28). This measurement indicated of segregation of six varieties of *Brassica* spp. into two main clusters: Safal, Agrani, Binasharisa-3, Binasharisa-4 and Binasharisa-5 grouped in cluster I, while Binasharisa-6 in cluster II (Fig. 33).

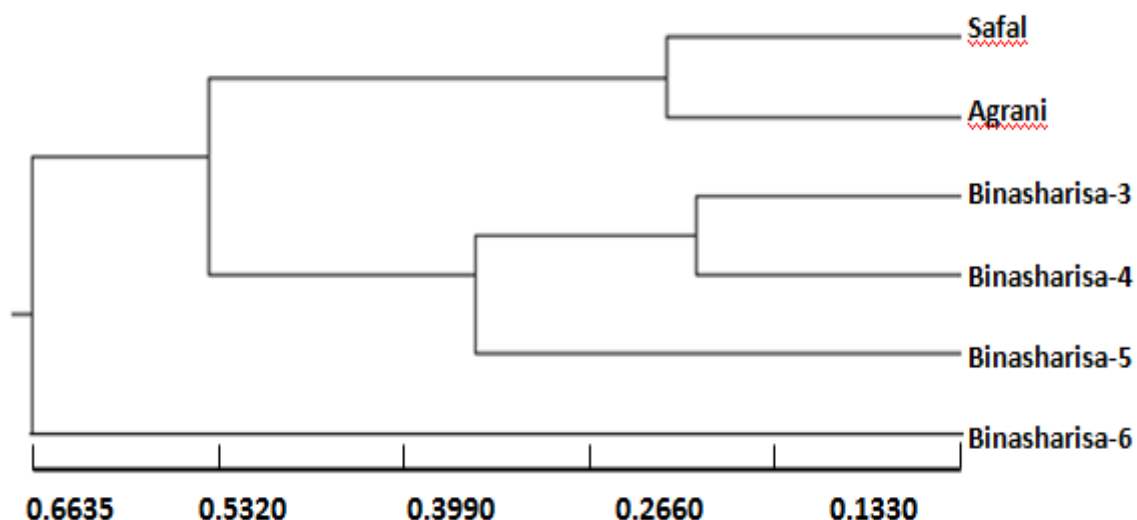


Fig. 33. UPGMA dendrogram based on Nei's (1972) genetic distance, summarizing the data on differentiation between six *Brassica* spp. varieties according to RAPD analysis

The Agrani cultivar close to the Safal cultivar with the lowest genetic distance (0.1082) and highest genetic distance (0.6635) was found between Safal and Binasharisa-6. In cluster I, the morphological characteristics such as seed colour are probably indicated in Safal and Agrani (yellow), Binasharisa-3, Binasharisa-4 and Binasharisa-5 (brown). Through cluster analysis, Das *et al.* (1999) reported that yellow seeded *Brassica* cultivars clearly separated from brown seeded cultivars. In cluster II, Binasharisa-6 has light yellow seed coat colour. The results are in consistent with the fact that the low or high level of genetic distance exists between cultivars with their same or different origins. A collection of varieties was studied using RAPDs to show a degree of diversity among genotypes. The information can be used in breeding programmes. It has been proved that RAPD can be suitable and efficient tool for genetic characterization of many plant species including oilseed rape (Hu *et al.*, 1999).

Molecular Characterization of four Mustard germplasm using RAPD markers

Out of 9, four different mustard germplasm were analyzed as a group for RAPD analysis. The five primers initially tested among them, two primers (**OPA-02 and OPB-06**) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of RAPD markers is shown in Fig. 34.

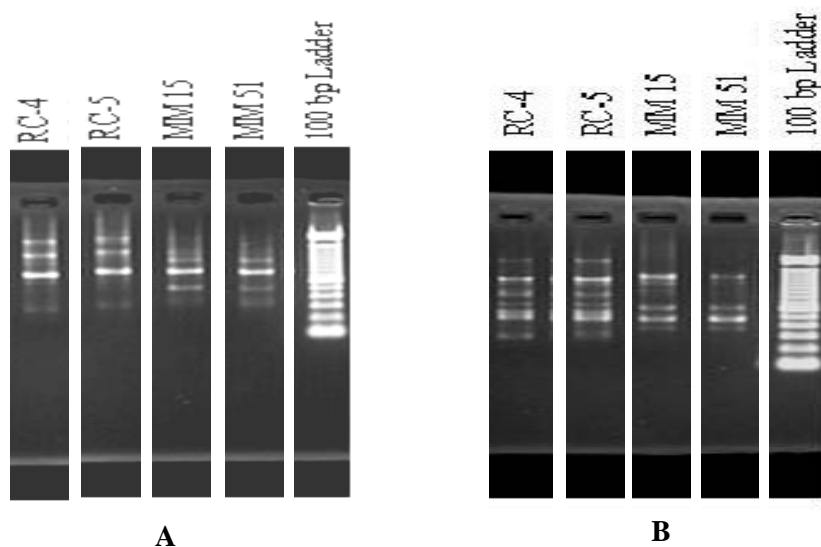


Fig. 34. RAPD profile of 4 mustard germplasm using primer A) OPA 02 and B) OPB 06

Crop: Sesame (*Sesamum indicum*)

Morphological Characterization of Sesame varieties/germplasm

The experiment was conducted at the farms of BINA Head Quarter during kharif-I of 2013. There were two varieties (Binatil-1 and Baritil-2) and six germplasm. The varieties and germplasm were laid out in a randomized complete block design with three replications. Unit plot size was 4m x 3m keeping 25 cm spacing between rows and 8-10 cm between plants. Seeds were sown in the last week of February 2013. Recommended production package like application of recommended doses of fertilizers, weeding, thinning, irrigation, application of pesticide etc. were followed to ensure normal plant growth and development. Morphological characterization and identification of the traits of documentation for distinctness of the varieties/germplasm were recorded and photograph taken from the field using the approved descriptors of IBPGR and IPGRI. All the data are presented in Table 24 & 25 and Fig. 35 & 36. Non-branching or unicum habitat is found in Binatil-1 which is very prominent characteristic in sesame variety.

Table 24. Distinctness of the morphological characters of sesame varieties

Sl. No.	State of the characters	Binatil-1	Binatil-2
1.	Branching habit	Non-branching	Branching
2.	Leaf position	Alternate	Alternate
3.	Growth	Indeterminate	Indeterminate
4.	Capsule shape	Broad oblong	Narrow oblong
5.	Shattering in the field	Shattered	Non-shattered
6.	Seed coat colour	Cream	Black
7.	Number of flowers per leaf axil	3-6	1-2
8.	Number of nodes to first flower	3-5	4-6
9.	Internode length (cm)	4.2	4.7
11.	Seeds per capsule	75-80	60-65
12.	Number of capsules/plant	80-100	65-75
13.	1000 -seed weight (g)	3.4-4.0	3.0-3.5
14.	Days to maturity	85-90	90-95
15.	Yield/plant (g)	25-30	20-25



Leaf (ventral side)



Leaf (dorsal side)



Plant



Stem



Flower



Fruit bearing habit



Seed



Fruit

Binatil-2

Fig. 35. Photograph showing different parts of sesame varieties

Table 25. Distinctness of the morphological characters of sesame germplasm

Sl. No.	State of the characters	SM- Black	SM- 8	SM- 058
1.	Branching habit	Branching	Non- branching	Non- branching
2.	Leaf position	Alternate	Alternate	Alternate
3.	Growth	Indeterminate	Indeterminate	Indeterminate
4.	Capsule shape	Narrow Oblong	Narrow Oblong	Narrow Oblong
5.	Shattering in the field	Shattered	Shattered	Shattered
6.	Seed coat colour	Black	Black	Black
7.	Number of flowers per leaf axil	1-2	2-3	2-3
8.	Number of nodes to first flower	4-6	4-6	5-7
9.	Internode length (cm)	4.3-4.6	4.0-4.5	5.0-5.5
10.	Capsule Length (cm)	1.8- 2.3	2.0-2.5	2.2-2.5
11.	Seeds per capsule	46-52	46-52	48-54
12.	Number of pod/plant	68- 76	75-80	72-76
13.	1000 -seed weight (g)	2.0-2.3	1.8-2.1	1.6-2.0
14.	Yield/plant (g)	12-14	10-12	10-12

Table 25. Cont'd

Sl. No.	State of the characters	SM- 067	SM- 10-4	SM- 9
1.	Branching habit	Branching	Branching	Branching
2.	Leaf position	Alternate	Alternate	Alternate
3.	Growth	Indeterminate	Indeterminate	Indeterminate
4.	Capsule shape	Narrow Oblong	Narrow Oblong	Narrow Oblong
5.	Shattering in the field	Shattered	Shattered	Non- shattered
6.	Seed coat colour	Black	Brown	Black
7.	Number of flowers per leaf axil	3-4	2-3	2-3
8.	Number of nodes to first flower	4-6	4-6	4-7
9.	Internode length (cm)	5.0-5.5	4.4- 5.2	4.2-4.5

Table 25. Cont'd

Sl. No.	State of the characters	SM- 067	SM- 10-4	SM- 9
10.	Capsule Length (cm)	2.2-2.56	2.0-2.3	1.8- 2.1
11.	Seeds per capsule	48-54	40-46	42-46
12.	Number of pod/plant	76-76	70-78	68- 76
13.	1000 -seed weight (g)	1.6-2.0	1.7-2.0	2.0-2.1
14.	Yield/plant (g)	11-13	10-12	10-12



Leaf (ventral side)



Leaf (dorsal side)



Stem



Flower



Fruit bearing habit



Fruit



Root

SM-BLACK



Leaf (ventral side)



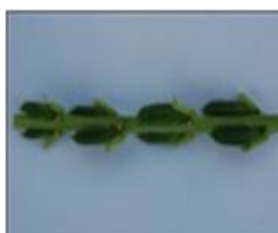
Leaf (dorsal side)



Stem



Flower



Fruit bearing habit



Fruit



Root

SM-067

Fig. 36. Photograph showing different parts of sesame germplasm



Leaf (ventral side)



Leaf (dorsal side)



Stem



Flower



Fruit bearing habit



Fruit



Root

SM-058



Leaf (ventral side)



Leaf (dorsal side)



Stem



Flower



Fruit bearing habit



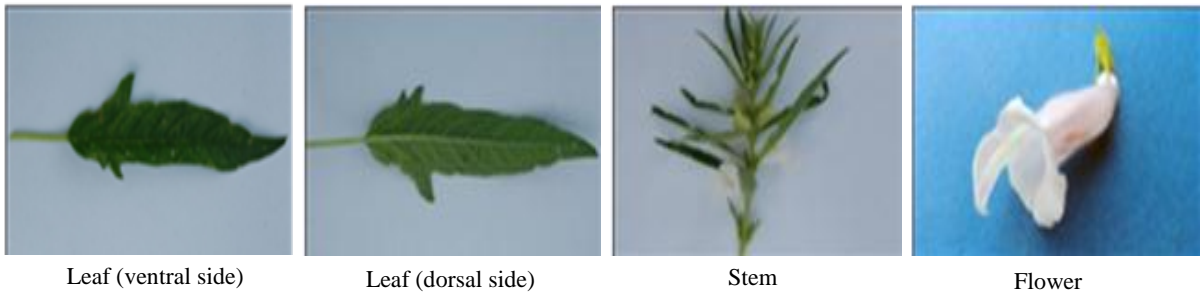
Fruit



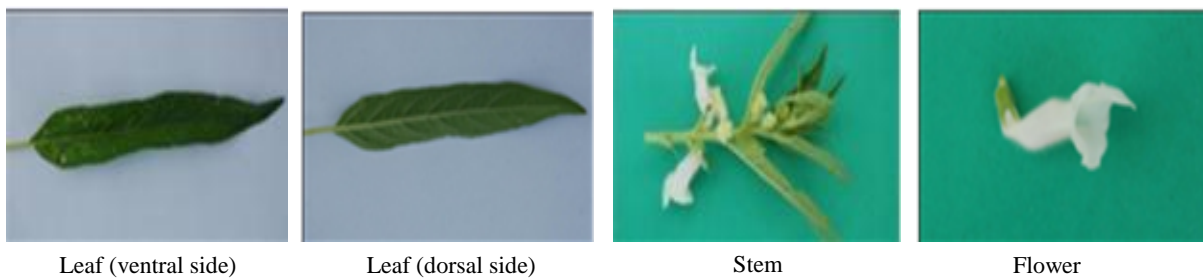
Root

SM-8

Fig. 36. Cont'd



SM-9



SM-10-4

Fig. 36. Cont'd

Molecular Characterization of five Sesame germplasm using RAPD markers

Out of 8, six different Sesame germplasm were characterized using RAPD markers. The six primers initially tested among them, two primers (**OPA-02**, **OPB-06** and **P21**) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of RAPD markers is shown in Fig. 37(a & b). Other sesame germplasm are being tested for molecular analysis.

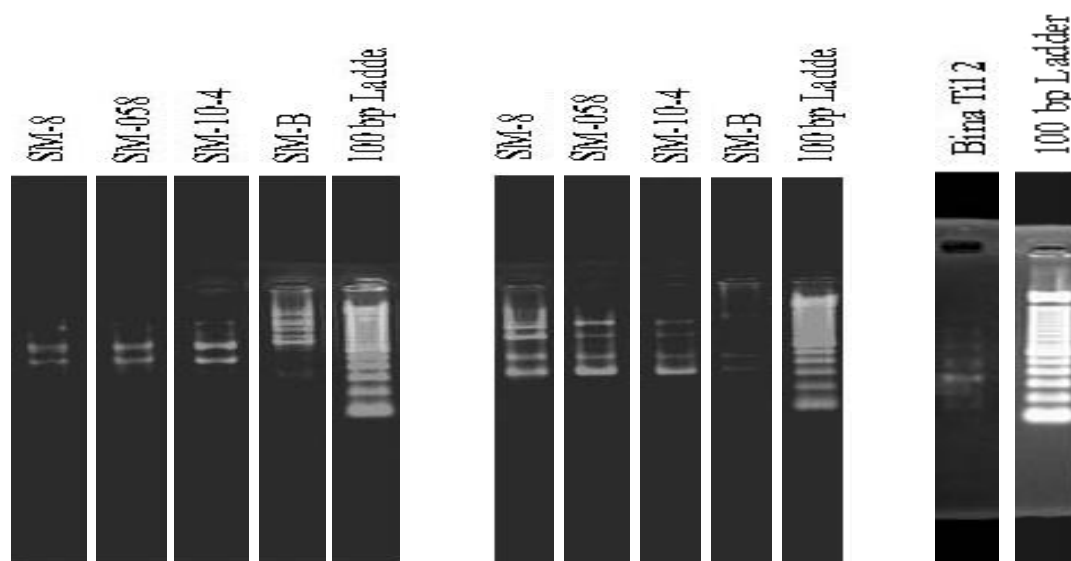


Fig. 37a. RAPD profiles of 4 Sesame germplasm using primer A) OPA02 and B) OPB06

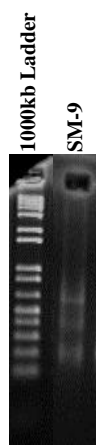


Fig. 37b. RAPD profiles of one Sesame germplasm using primer P21

Crop: Tomato (*Lycopersicum esculentum*)**Morphological Characterization of Tomato varieties/germplasm**

An experiment was conducted with 7 tomato varieties and 14 germplasm (instead of 10) at BINA Head Quarter farm during winter of 2012-13. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 5m x 4m having spacing of 50cm between both rows and plants in a row. Recommended cultural practices were followed as and when necessary. Data on different parameters of tomato according to IBPGR/IPGRI were recorded and photograph from the field and are presented in Table 26 & 27 and Fig. 38 & 39. Different fruit shapes are found in Tomato varieties and germplasm.

Table 26. Distinctness of the morphological characters of tomato varieties

State of the characters	Bahar	Bina tomato-2	Bina tomato-3	Bina tomato-4	Bina tomato-5	Bina tomato-6	Bina tomato-7
Plant growth type	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate
Plant size	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Plant height (cm)	105	94	118	97	103	110	115
Stem pubescence density	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse
Leaf type	Standard	Standard	Standard	Standard	Standard	Standard	Standard
Anthocyanin colouration of leaf veins	Obscure vein	Obscure vein	Obscure vein	Clear	Obscure vein	Obscure vein	Clear
Inflorescence type	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous
Corolla colour	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Corolla blossom type	Open	Open	Open	Open	Open	Open	Open
Exterior colour of Immature fruit	Grreen	Grreen	Grreen	Grreen	Grreen	Grreen	Grreen
Presence of green (shoulder) trips on the fruit	Present	Present	Present	Absent	Present	Present	Present
Intenslty of greenback	Strong	Strong	Strong	Slight	Strong	Slight	Slight
Fruit pubescence	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse
Predominant fruit shape	Slightly flattened	Slightly flattened	Flattened	High rounded	Ellipsoid	Slightly flattened	High rounded
Fruit size	Very large	Small	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Fruit size homogeneity	Low	High	Low	High	High	Medium	Low
Fruit wt. (g)	100-150	40-50	55-60	45-50	35-40	60-65	55-60
Exterior colour of mature fruit	Green	Green	Green	Green	Green	Green	Green

Table 26. Cont'd

State of the characters	Bahar	Bina tomato-2	Bina tomato-3	Bina tomato-4	Bina tomato-5	Bina tomato-6	Bina tomato-7
Intensity of exterior colour	Intermediate	Light	Intermediate	Light	Light	Intermediate	Dark
Presence /absence of jointless pedicel	Present	Present	Present	Present	Present	Present	Present
Size of corky area around pedicel scar	Large	Medium	Large	Small	Small	Medium	Medium
Easiness of fruit wall (skin) to be peeled	Intermediate	Easy	Easy	Easy	Easy	Intermediate	Intermediate
Skin colour of ripe fruit	Colourless	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Flesh colour of pericarp (interior)	Red	Orange	Red	Red	Red	Orange	Red
Flesh colour intensity	Intermediate	Light	Dark	Light	Light	Intermediate	Dark
Colour (intensity) of core	Green	Light	Intermediate	Light	Intermediate	Green	Green
Fruit cross section shape	Irregular	Round	Irregular	Round	Round	Round	Round
Shape of pistil scar	Irregular	Dot	Stellate	Dot	Dot	Dot	Dot
Fruit blossom and shape	Indented	Flat	Indented	Flat	Indented	Flat	Flat
Blossom and scar condition	Closed	Closed	Closed	Closed	Closed	Closed	Closed
Fruit firmness (after storage)	Firm	Firm	Firm	Intermediate	Intermediate	Firm	Firm
Seed shape	Ovate	Ovate	Globular	Ovate	Ovate	Ovate	Ovate
Secondary fruit shape	Slightly flattened	Rounded	Flattened	Rounded	Cylindrical	Rounded	Rounded



Leaf (ventral side)



Leaf (dorsal side)



Stem



Inflorescence



Flower



Fruit

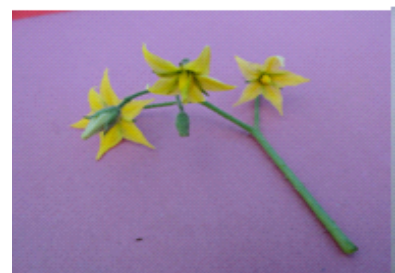
Bahar



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

Binatomato-2

Fig. 38. Photograph showing different parts of tomato varieties



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

Binatomato-3



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

Binatomato-4

Fig. 38. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

Binatomato-5



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower

Binatomato-6

Fig. 38. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

Binatomato-7

Fig. 38. Cont'd

Table 27. Distinctness of the morphological characters of tomato germplasm

State of the characters	TM-219	TM-131	TM-134	CLN2413R	CLN3070A	AMTOV1010
Plant growth type	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate
Plant size	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Plant height (cm)	107	112	120	95	98	102
Stem pubescence density	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse
Leaf type	Standard	Standard	Standard	Standard	Standard	Standard
Anthocyanin colouration of leaf veins	Clear	Clear	Clear	Clear	Clear	Clear
Inflorescence type	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous
Corolla colour	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Corolla blossom type	Open	Open	Open	Open	Open	Open
Exterior colour of Immature fruit	Green	Green	Green	Green	Green	Green
Presence of green (shoulder) trips on the fruit	Absent	Absent	Absent	Absent	Absent	Present
Intensity of greenback (green shoulder)	Slight	Slight	Slight	Slight	Slight	Intermediate
Fruit pubescence	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse
Predominant fruit shape	Slightly flattened	Cylindrical	Cylindrical	Cylindrical	Cylindrical	Slightly flattened
Fruit size	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Fruit size homogeneity	Intermediate	High	High	High	High	Intermediate

Table 27. Cont'd

State of the characters	ANOBK	TM-20	TM-19	TM-11	TM-13	TM-8	TM-14	TM-110
Plant growth type	Determinate	Intermediate	Intermediate	Determinate	Determinate	Determinate	Determinate	Determinate
Plant size	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Plant height (cm)	70-80	110-115	115-120	95-100	95-100	115-120	115-120	115-120
Stem pubescence density	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse
Leaf type	Standard	Standard	Standard	Standard	Standard	Standard	Standard	Standard
Anthocyanin colouration of leaf veins	Clear	Obscure vein	Obscure vein	Clear	Clear	Clear	Clear	Clear
Inflorescence type	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous	Uniparous
Corolla colour	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Corolla blossom type	Open	Open	Open	Open	Open	Open	Open	Open
Exterior colour of Immature fruit	Grreen	Grreen	Grreen	Grreen	Grreen	Grreen	Grreen	Grreen
Presence of green (shoulder) trips on the fruit	Present	Absent	Absent	Absent	Present	Present	Present	Present
Intenslty of greenback (green shoulder)	Strong	Slight	Slight	Slight	Strong	Slight	Slight	Strong
Fruit pubescence	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse	Sparse
Predominant fruit shape	rounded	Ovate and Small	Ovate and Small	rounded	rounded	rounded	High rounded	High rounded
Fruit size	Intermediate	Small	Small	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
Fruit size homogeneity	High	Low	Low	High	High	High	Low	High



Leaf (ventral side)



Leaf (dorsal side)



Flower



Fruit

TM-134



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

TM-219

Fig. 39. Photograph showing different parts of tomato germplasm



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

CLN 2413R



Leaf (ventral side)



Flower



Leaf (dorsal side)



Inflorescence



Fruit

AMTOV 1010

Fig. 39. Cont'd



Leaf (ventral side)



Leaf (dorsal side)



Inflorescence



Flower



Fruit

CLN 3070J



Leaf (dorsal side)



Leaf (ventral side)



Inflorescence



Flower



Green fruit



Ripen fruit



Fruit (Section)

TM-110

Fig. 39. Cont'd



Leaf (dorsal side)



Leaf (ventral side)



Inflorescence



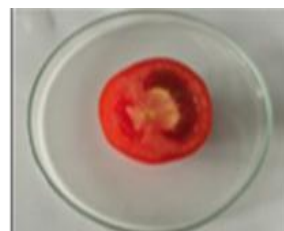
Flower



Green fruit



Ripen fruit



Fruit (Section)

TM-14



Leaf (dorsal side)



Leaf (ventral side)



Inflorescence



Flower



Green fruit



Ripen fruit



Fruit (Section)

TM-8

Fig. 39. Cont'd



Leaf (dorsal side)



Leaf (ventral side)



Inflorescence



Flower



Green fruit



Ripen fruit



Fruit (Section)

TM-13



Leaf (dorsal side)



Leaf (ventral side)



Inflorescence



Flower



Green fruit



Ripen fruit



Fruit (Section)

TM-11

Fig. 39. Cont'd



Leaf (dorsal side)



Leaf (ventral side)



Inflorescence



Flower



Green fruit



Ripen fruit



Fruit (Section)

TM-19



Leaf (dorsal side)



Leaf (ventral side)



Inflorescence



Flower



Green fruit



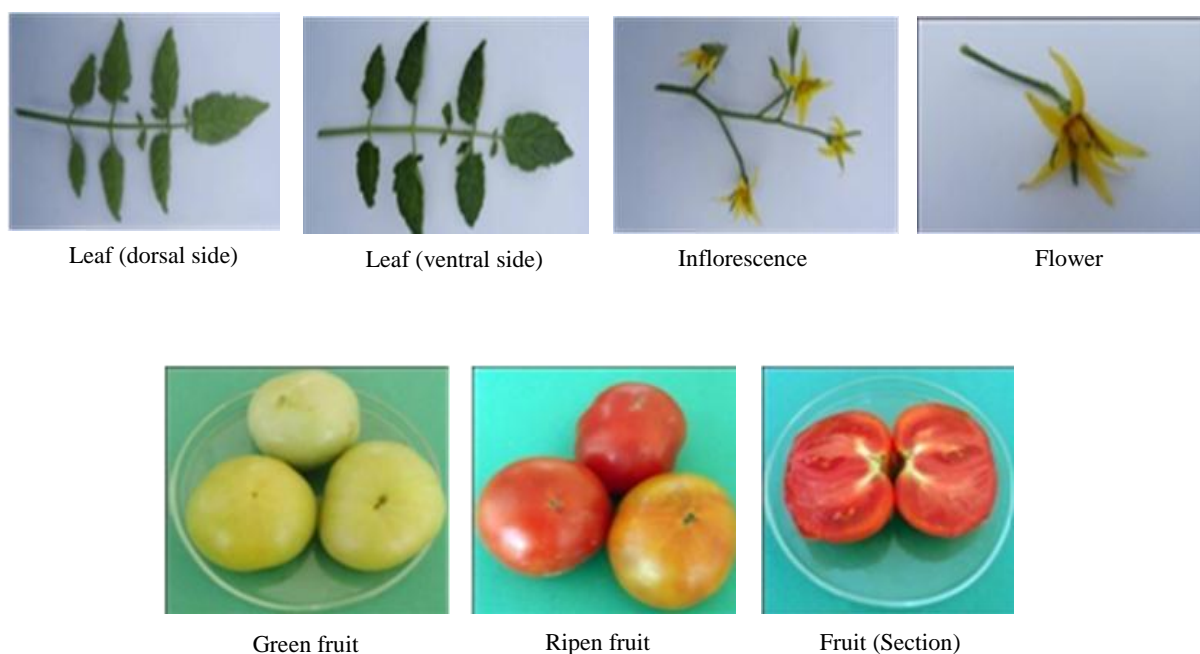
Ripen fruit



Fruit (Section)

TM-20

Fig. 39. Cont'd



ANOBIK

Fig. 39. Cont'd

Molecular Characterization of ten Tomato germplasm

Out of 21, 12 different tomato germplasm were characterized using SSR markers. The seven primers initially tested among them, three primers (**SSR 136**, **SSR80**, **LEata004** and **SSR 139**) produced comparatively higher number of amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of SSR markers is shown in Fig. 40 (a & b). Other tomato germplasm were not genotyped due to time constrain.

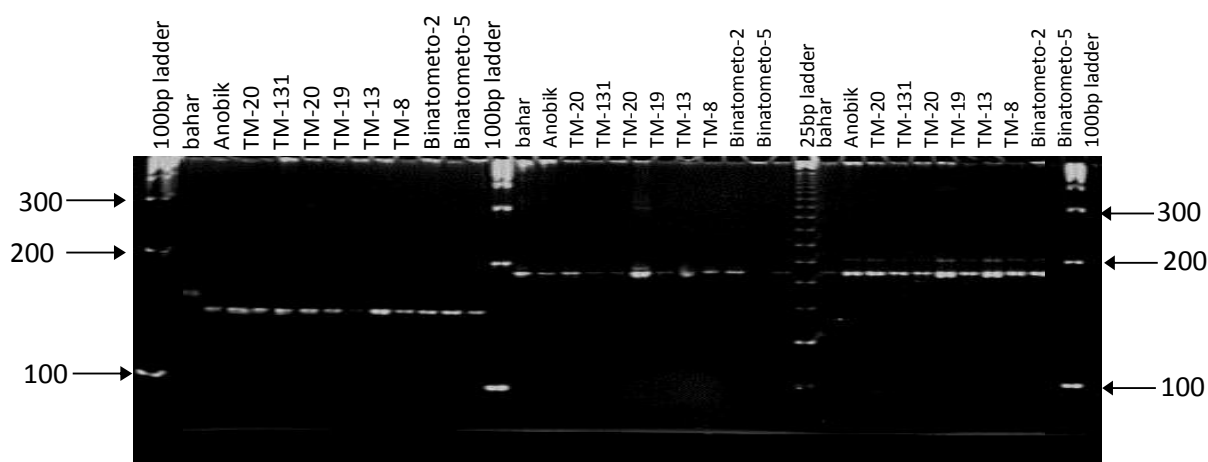


Fig. 40a. Microsatellite profiles of five tomato germplasm at loci SSR 136, SSR80 and LEata004

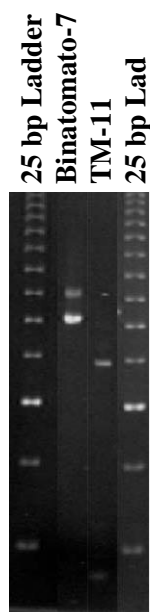


Fig. 40b. Microsatellite profile of two tomato germplasm at loci SSR 139

Crop: Rice (*Oryza sativa*)

Morphological Characterization of Rice varieties/germplasm

Eight varieties (instead of 7) and 60 germplasm were evaluated during the T. aman, 2012 for morpho-physiological and molecular characterization. The experiment was set at BINA Head Quarter Farm. Thirty day old seedlings were used for transplantation. Unit plot size was 5m x 0.4m. Spacing between hills, rows, plots and replications were 15 and 20 cm, respectively. Normal cultural practices were done as and when necessary. Data were recorded from each germplasm according to descriptor of IBPGR/IPGRI and photograph taken and presented in Table 28 & 29 and Fig. 41. Rice varieties and germplasm are distinctly different with respect to grain colour, grain size-shape and length-breadth. Binadhan-10 possesses enclosed panicle exertion while Binadhan-7 and Binadhan-8 are well and moderately exerted, respectively. Flag leaf varies genotype to genotype as erect, semi-erect and horizontal.

Table 28. Distinctness of the morphological characters of rice varieties

SL. No.	Characteristics	Iratom-24	Binasail	Bina dhan-4	Bina dhan-5	Bina dhan-6
		State	State	State	State	State
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Green	Green	Green	Green	Green
3.	Penultimate leaf pubescence	Absent	Medium	Medium	Medium	Medium

Table 28. Cont'd

SL. No.	Characteristics	Iratom-24	Binasail	Bina dhan-4	Bina dhan-5	Bina dhan-6
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Medium	Medium	Medium	Medium
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule	Split	Split	Split	Split	Split
7.	Flag leaf: attitude of the blade	Erect	Horizontal	Erect	Erect	Semi-erect
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium
9a.	Male sterility	-	-	-	-	-
9b.	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Absent	Absent	Absent	Absent	Absent
11.	Lemma: anthocyanin coloration of area below apex	Absent	Absent	Absent	Absent	Absent
12.	Lemma: anthocyanin coloration of apex	Absent	Absent	Absent	Absent	Absent
13a.	Color of stigma	White	White	White	White	White
13b.	Stigma exertion	High	Medium	High	Medium	High
14.	Stem: culm diameter(from 5 mother tillers in the lowest internode)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Short (41-60cm)	Long (81-110)cm	Medium (61-80)cm	Long (81-110)cm	Long (81-110)cm
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Medium	Medium	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Medium	Medium	Medium	Medium	Medium
21.	Panicle: number of the effective tillers per plant	Many	Many	Many	Many	Many

Table 28. Cont'd

SL. No.	Characteristics	Iratom-24	Binasail	Bina dhan-4	Bina dhan-5	Bina dhan-6
22.	Spikelet: pubescence of lemma & palea	weak	weak	weak	weak	weak
23.	Spikelet: color of tip of lemma	Yellow	Yellow	Yellow	Yellow	Yellow
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	-	-
26a.	Panicle: distribution of awns	-	-	-	-	-
26b.	Panicle: color of a awns	-	-	-	-	-
27.	Panicle: attitude of branches	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect
28.	Panicle: exertion	Well exerted	Well exerted	Well exerted	Well exerted	Well exerted
29.	Time of maturity	Medium	Medium	Late	Late	Late
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture)	Medium	Medium	Medium	Medium	Medium
31.	Grain: length (without dehulling)	Medium	Medium	Medium	Medium	Medium
32.	Sterile lemma length: Measure at post harvest stage	Long	Long	Long	Long	Long
33.	Decorticated grain: length (after dehulling, before milling)	Medium	Medium	Medium	Medium	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Ealy and fast	Ealy and fast	Late and slow	Late and slow	Late and slow
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Medium	Medium	Medium	Medium	Medium
36.	Decorticated grain (bran): color	Light brown	Light brown	Light brown	Light brown	Light brown
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-
38.	Endosperm: content of amylose (Non-waxy type varieties)	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)	-	-	Late	Very Late	Early

Table 28. Cont'd

Sl No.	Characters	Binadhan-7	Binadhan-8	Binadhan-10
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent
2.	Leaf color	Green	Dark green	Dark green
3.	Penultimate leaf pubescence	Absent	Absent	Absent
4.	Anthocyanin coloration of auricles & collar	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present
6.	Penultimate leaf: shape of the legule	Acute	Split	Split
7.	Flag leaf : attitude of the blade	Erect	Erect	Erect
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium
9a.	Male sterility	Absent	Absent	Absent
9b.	Microscopic observation of pollen with I ₂ -KI solution	Fully fertile	Fertile	Fertile
10.	Lemma & palea : anthocyanin coloration	Absent	Absent	Absent
11.	Lemma: anthocyanin coloration of area below the apex	Absent	Absent	Absent
12.	Lemma: anthocyanin coloration of apex	Absent	1 Absent	Absent
13a.	Colour of stigma	White	White	White
13b.	Stigma exertion	A few	A few	A few
14.	Stem: Culm diameter (from 5 mother tillers in the lowest internode)	Medium	Large	Large
15.	Stem length (culm length): measure from the base of the plant to the neck of the panicles	Medium	Medium	Medium
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent
17.	Stem: intensity of anthocyanin coloration of nodes	-	Weak	Weak
18.	Stem: anthocyanin coloration of internodes	Absent	Absent	Absent
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Very strong	Strong	Strong
21.	Panicle: number of the effective tillers per plant	Medium	Medium	Medium
22.	Spikelet: pubescence of lemma & palea	Absent	Medium	Medium
23.	Spikelet: colour of tip of lemma	White	Yellowish	Yellowish
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-
26a.	Panicle: distribution of the awns	-	-	-
26b.	Panicle: colour of awns	-	-	-
27.	Panicle: attitude of branches	Erect	Semi erect	Semi erect
28.	Panicle: exertion	Well exerted	Moderately exerted	Enclosed

Table 28. Cont'd

Sl No.	Characters	Binadhan-7	Binadhan-8	Binadhan-10
29.	Time of maturity	Medium	Medium	Medium
30.	Grain: Weight of 1000 fully developed grain (adjusted at 12% of moisture)	High	Medium	Medium
31.	Grain: Length (without de-hulling)	Very short	Medium	Medium
32.	Sterile lemma length: measure of post harvest stage	Very long	Medium	Medium
33.	Decorticated grain: length (after de-hulling, before milling)	Long	Medium	Medium
34.	Leaf senescence: penultimate leaves are observed at the time of harvest	Late and slow	Late and slow	Late and slow
35.	Decorticated grain: shape (length-width (widest point) ratio of de-hulled grain)	Slender	Bold	Medium
Sl No.	Characters	Binadhan-7	Binadhan-8	Binadhan-10
36.	Decorticated grain (bran): colour	White	Intermediate	Intermediate
37.	Polished grain: size of white core or chalkiness (% of karnel area)	Absent	Medium	Medium
38.	Endosperm: content of amylose (non-waxy type varieties)	—	White	White
39.	Decorticated grain: aroma	Absent	Medium	Medium
40.	Other distinct special character (if any)	—		

Table 29. Distinctness of the morphological characters of rice germplasm

Sl. No.	Characteristics	Hati bajore	Malagoti	Kajol Shail	Hogla	Jamai naru	Dhak shail	Patnai
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Green	Dark green	Dark green	Green	Dark green	Dark green	Green
3.	Penultimate leaf pubescence	Absent	Medium	Medium	Absent	Absent	Medium	Weak
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present	Present	Present

Table 29. Cont'd

Sl. No.	Characteristics	Hati bajore	Malagoti	Kajol Shail	Hogla	Jamai naru	Dhak shail	Patnai
6.	Penultimate leaf: shape of the ligule	Acute	Acute	Acute	Acute	Acute	Acute	Acute
7.	Flag leaf: attitude of the blade	Horizontal	Horizontal	Erect	Horizontal	Horizontal	Semi-erect	Erect
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium
9.a	Male sterility	-	-	-	-	-	-	-
9.b	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Medium	Absent	Absent	Medium	Absent	Absent	Absent
11.	Lemma: anthocyanin coloration of area below apex	Medium	Absent	Absent	Medium	Absent	Absent	Absent
12.	Lemma: anthocyanin coloration of apex	Weak	Absent	Absent	Absent	Absent	Absent	Weak
13.a	Color of stigma	White	White	White	White	White	White	White
13.b	Stigma exertion	High	Medium	High	Medium	High	Medium	High
14.	Stem: culm diameter(from 5 mother tillers in the lowest internode)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Long (81-110)cm	Short (41-60cm)	Medium (61-80)cm	Long (81-110)cm	Long (81-110)cm	Long (81-110)cm	Long (81-110)cm
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Table 29. Cont'd

Sl. No.	Characteristics	Hati bajore	Malagoti	Kajol Shail	Hogla	Jamai naru	Dhak shail	Patnai
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-	-	-
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Medium	Medium	Medium	Medium	Long
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Medium	Weak	Medium	Weak	Weak	Weak	Weak
21.	Panicle: number of the effective tillers per plant	Many (>10)	Many (>10)	Many (>10)	Medium (6-10)	Many (>10)	Many (>10)	Few (<6)
22.	Spikelet: pubescence of lemma & palea	Medium	weak	Medium	Medium	weak	weak	weak
23.	Spikelet: color of tip of lemma	Yellow	Yellow	Purple	Purple	Yellow	Brown	Brown
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Present	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	Very short	-	-	-
26.a	Panicle: distribution of awns	-	-	-	Tip only	-	-	-
26.b	Panicle: color of a awns	-	-	-	Yellow white	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Hati bajore	Malagoti	Kajol Shail	Hogla	Jamai naru	Dhak shail	Patnai
27.	Panicle: attitude of branches	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Spreading	Spreading
28.	Panicle: exertion	Just exerted	Partly Exerted	Well exerted	Just exerted	Well exerted	Well exerted	Well exerted
29.	Time of maturity	Late	Medium	Medium	Late	Late	Medium	Late
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture) (g)	30.0	19.3	27.4	26.8	29.0	20.4	27.5
31.	Grain: length (without dehulling)	Medium	Short	short	Medium	Medium	Very short	Medium
32.	Sterile lemma length: Measure at post harvest stage	Very long	Very long	Very long	Very long	Very long	Long	Very long
33.	Decorticated grain: length (after dehulling, before milling)	Medium	Medium	Medium	Medium	Medium	Short	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Ealy and fast	Ealy and fast	Ealy and fast	Late And slow	Ealy and fast	Ealy and fast	Intermediate
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Bold	Bold	Bold	Bold	Bold	Bold	Medium
36.	Decorticated grain (bran): color	Light brown	Light brown	Light brown	Light brown	Light brown	Light brown	White

Table 29. Cont'd

Sl. No.	Characteristics	Hati bajore	Malagoti	Kajol Shail	Hogla	Jamai naru	Dhak shail	Patnai
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-	-	--
38.	Endosperm: content of amylose (Non-waxy type varieties)	-	-	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)	-	-	-	-	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Bhute shalot	Kute patnai	Khak shail	Mohime	Holde gotal	Jota balam	Bazra muri
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Green	Green	Dark green	Green	Green	Dark green	Dark green
3.	Penultimate leaf pubescence	Absent	Absent	Absent	Absent	Absent	Weak	Weak
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule	Acute	Acute	Acute	Acute	Acute	Acute	Acute
7.	Flag leaf: attitude of the blade	Horizontal	Erect	Erect	Horizontal	Erect	Erect	Horizontal
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Table 29. Cont'd

Sl. No.	Characteristics	Bhute shalot	Kute patnai	Khak shail	Mohime	Holde gotal	Jota balam	Bazra muri
9.(a)	Male sterility	-	-	-	-	-	-	-
9.(b)	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Absent	Absent	Absent	Absent	Absent	medium	Absent
11.	Lemma: anthocyanin coloration of area below apex	Absent	Absent	Absent	Absent	Absent	Medium	Absent
12.	Lemma: anthocyanin coloration of apex	Medium	Absent	Absent	Absent	Absent	Medium	Absent
13. (a)	Color of stigma	White	White	White	White	White	White	White
13. (b)	Stigma exertion	High	Medium	High	Medium	High	Medium	High
14.	Stem: culm diameter(from 5 mother tillers in the lowest internode)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Long (81-110)cm	Long (81-110)cm	Medium (61-80)cm	Medium (61-80)cm	Long (81-110)cm	Medium (61-80)cm	Long (81-110)cm
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-	-	-
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Table 29. Cont'd

Sl. No.	Characteristics	Bhute shalot	Kute patnai	Khak shail	Mohime	Holde gotal	Jota balam	Bazra muri
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Long	Long	Medium	Long	Long	Medium	Long
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Medium	Weak	Medium	Weak	Absent	Medium	Weak
21 .	Panicle: number of the effective tillers per plant	Medium (6-10)	Medium (6-10)	Medium (6-10)	Many (>10)	Many (>10)	Many (>10)	Medium (6-10)
22 .	Spikelet: pubescence of lemma & palea	Medium	weak	Medium	Medium	weak	Medium	weak
23 .	Spikelet: color of tip of lemma	Black	Brown	Black	Black	Brown	Purple	Brown
24 .	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Present	Absent	Absent
25 .	Spikelet: length of the longest awn	-	-	-	-	-	-	-
26. (a)	Panicle: distribution of awns	-	-	-	-	-	-	-
26. (b)	Panicle: color of awns	-	-	-	-	-	-	-
27.	Panicle: attitude of branches	Spreading	Spreading	Spreading	Semi-erect	Semi-erect	Spreading	Spreading

Table 29. Cont'd

Sl. No.	Characteristics	Bhute shalot	Kute patnai	Khak shail	Mohime	Holde gotal	Jota balam	Bazra muri
28.	Panicle: exertion	Moderately exerted	Moderately exerted	Partly exerted	Just exerted	Well exerted	Well exerted	Well exerted
29.	Time of maturity	Medium	Medium	Medium	Medium	Medium	Late	Late
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture) (g)	26.3	26.9	30.0	27.3	27.3	29.2	22.9
31.	Grain: length (without dehulling)	Short	Medium	Long	Long	Medium	Medium	Medium
32.	Sterile lemma length: Measure at post harvest stage	Very long	Very long	Very Long	Very long	Very long	Very long	Very long
33.	Decorticated grain: length (after dehulling, before milling)	Short	Short	long	Medium	medium	Long	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Early and Fast	Intermediate	Early and Fast	Early and Fast	Early and Fast	Late And slow	Early and Fast

Table 29. Cont'd

Sl. No.	Characteristics	Bhute shalot	Kute patnai	Khak shail	Mohime	Holde gotal	Jota balam	Bazra muri
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Bold	Bold	Medium	Medium	Bold	Bold	Bold
36.	Decorticated grain (bran): color	Light brown	Dark Brown	Light brown	White	White	White	White
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-	-	-
38.	Endosperm : content of amylose (Non-waxy type varieties)	-	-	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)	-	-	-	-	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Ghunshi	Hamai	Lal gotal	Karengal	Kalomota	Mondeshor	NDNA kochi
		State	State	State	State	State	State	State
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Dark green	Dark green	Dark green	Green	Dark green	Green	Green
3.	Penultimate leaf pubescence	Absent	Absent	Absent	Weak	Absent	Absent	Absent
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule	Acute	Split	Acute	Acute	Acute	Split	Acute
7.	Flag leaf: attitude of the blade	Erect	Erect	Reflexed	Horizontal	Horizontal	Horizontal	Horizontal
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium
9. (a)	Male sterility	-	-	-	-	-	-	-
9. (b)	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Weak	Absent	Medium	medium	Absent	Medium	medium

Table 29. Cont'd

Sl. No.	Characteristics	Ghunshi	Hamai	Lal gotal	Karengal	Kalomota	Mondeshor	NDNA kochi
11.	Lemma: anthocyanin coloration of area below apex	Medium	Absent	Medium	Medium	Absent	Weak	Medium
12.	Lemma: anthocyanin coloration of apex	Very strong	Absent	Weak	Medium	Absent	Very strong	Medium
13. (a)	Color of stigma	Purple	White	White	White	White	White	White
13. (b)	Stigma exertion	High	Very high	High	Medium	High	Medium	High
14.	Stem: culm diameter(from 5 mother tillers in the lowest internode)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Medium (61-80)cm	Long (81-110)cm	Long (81-110)cm	Medium (61-80)cm	Long (81-110)cm	Long (81-110)cm	Long (81-110)cm
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-	-	-
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Long	Long	Long	Long	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Weak	Weak	Weak	Medium	Weak	Medium	Weak

Table 29. Cont'd

Sl. No.	Characteristics	Ghunshi	Hamai	Lal gotal	Karengal	Kalomota	Mondeshor	NDNA kochi
21.	Panicle: number of the effective tillers per plant	Many (>10)	Many (>10)	Medium (6-10)	Many (>10)	Medium (6-10)	Medium (6-10)	Medium
22.	Spikelet: pubescence of lemma & palea	Medium	weak	weak	weak	weak	weak	Medium
23.	Spikelet: color of tip of lemma	Black	Brown	Brown	Yellow	Brown	Black	Black
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Present	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	-	-	-	-
26. (a)	Panicle: distribution of awns	-	-	-	-	-	-	-
26. (b)	Panicle: color of a awns	-	-	-	-	-	-	-
27.	Panicle: attitude of branches	Semi erect	Semi erect	Semi erect	Spreading	Semi-erect	Spreading	Spreading
28.	Panicle: exertion	Well exerted	Well exerted	Well exerted	Just exerted	Well exerted	Well exerted	Just exerted
29.	Time of maturity	Medium	Medium	Medium	Medium	Medium	Medium	Late
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture) (g)	21.4	23.7	31.3	28.5	26.1	31.8	29.1

Table 29. Cont'd

Sl.No.	Characteristics	Ghunshi	Hamai	Lal gotal	Karengal	Kalomota	Mondeshor	NDNA kochi
31.	Grain: length (without dehulling)	Short	Short	Short	Short	Medium	Medium	Medium
32.	Sterile lemma length: Measure at post harvest stage	Very Long	Very Long	Very Long	Very Long	Very Long	Very Long	Very Long
33.	Decorticated grain: length (after dehulling, before milling)	Short	Short	Medium	Medium	Medium	Medium	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Early and fast	Early and fast	Early and fast	Early and fast	Early and fast	Early and fast	Early and fast
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Bold	Bold	Bold	Bold	Bold	Bold	Bold
36.	Decorticated grain (bran): color	Light brown	Red	White	White	White	White	White
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-	-	-
38.	Endosperm: content of amylose (Non-waxy type varieties)	-	-	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)	-	-	-	-	-	-	-

Table 29. Cont'd

Sl. No	Characteristics	Tal mugur	Tor balam	Jolkum ri	Ponkhir aj	Dudh shail	Vushiar a	Machra nga
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent	Absent	Present
2.	Leaf color	Green	Green	Dark green	Dark green	Dark green	Dark green	Dark green
3.	Penultimate leaf pubescence	Absent	Absent	Absent	Absent	Absent	Weak	Medium
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent	Absent	Present
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule	Acute	Acute	Split	Acute	Split	Acute	Acute
7.	Flag leaf: attitude of the blade	Semi erect	Erect	Erect	Horizontal	Horizontal	Horizontal	Horizontal
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium
9.a	Male sterility	-	-	-	-	-	-	-
9.b	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Absent	Absent	Absent	Absent	Absent	Absent	Very strong

Table 29. Cont'd

Sl. No	Characteristics	Tal mugur	Tor balam	Jolkumri	Ponkhiraj	Dudh shail	Vushiara	Machranga
11.	Lemma: anthocyanin coloration of area below apex	Absent	Absent	Absent	Absent	Absent	Absent	Very Strong
12.	Lemma: anthocyanin coloration of apex	Absent	Absent	Absent	Absent	Absent	Strong	Very strong
13.(a)	Color of stigma	White	White	White	White	White	purple	purple
13.(b)	Stigma exertion	Very high	High	High	Medium	High	High	Very high
14.	Stem: culm diameter(from 5 mother tillers in the lowest internode)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Long (81-110)cm	Long (81-110)cm	Short (41-60)cm	Long (81-110)cm	Long (81-110)cm	Long (81-110)cm	Very long (81-110)cm
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Present
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-	-	Strong
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent	Absent	Strong
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Long	Medium	Medium	Long	Long	Long	Long
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Strong	Medium	Medium	Medium	Strong	Medium	Weak

Table 29. Cont'd

Sl. No	Characteristics	Tal mugur	Tor balam	Jolkumri	Ponkhiraj	Dudh shail	Vushiara	Machranga
21.	Panicle: number of the effective tillers per plant	Medium (6-10)	Many (>10)	Medium (6-10)	Many (>10)	Many (>10)	Many (>10)	Many (>10)
72.	Spikelet: pubescence of lemma & palea	weak	weak	weak	weak	weak	weak	medium
23.	Spikelet: color of tip of lemma	Brown	White	Brown	Yellow	Yellow	Purple	Purple
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Absent	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	-	-	-	-
26. (a)	Panicle: distribution of awns	-	-	-	-	-	-	-
26. (b)	Panicle: color of a awns	-	-	-	-	-	-	-
27.	Panicle: attitude of branches	Spreading	Semi-erect	Spreading	Spreading	Spreading	Semi-erect	Semi-erect
28.	Panicle: exertion	Just exerted	Just exerted	Partly exerted	Just exerted	Well exerted	Moderately exerted	Moderately exerted
29.	Time of maturity	Medium	Medium	Medium	Medium	Medium	Late	Medium
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture) (g)	30.1	26.5	24.0	23.0	20.4	29.1	24.5
31.	Grain: length (without dehulling)	Medium	Long	Short	Short	Long	Short	Short
32.	Sterile lemma length: Measure at post harvest stage	Long	Very long	Very long	Very long	Very Long	Very long	Very long
33.	Decorticated grain: length (after dehulling, before milling)	Medium	Long	Short	Short	long	Short	Medium

Table 29. Cont'd

Sl. No	Characteristics	Tal mugur	Tor balam	Jolkumri	Ponkhira j	Dudh shail	Vushiara	Machrang a
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Early and fast	Early and Fast	Early and Fast	Early and Fast	Early and Fast	Early and Fast	Early and Fast
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Bold	Medium	Bold	Bold	Medium	Bold	Bold
36.	Decorticated grain (bran): color	Light brown	White	White	White	Light brown		Dark brown
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-	-	-
38.	Endosperm: content of amylose (Non-waxy type varieties)	-	-	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)	-	-	-	-	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Gota	Rajshahi balam	Kathi goccha	Pengek	lal-40	Ranga hogla	Gota mala
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Green	Green	Dark green	Purple tip	Green	Dark green	Dark green
3.	Penultimate leaf pubescence	Absent	Absent	Absent	Absent	Absent	Weak	Weak
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Weak	Weak	Medium	Absent	Weak	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule							
7.	Flag leaf: attitude of the blade	Horizontal	Semi erect	Erect	Horizontal	Horizontal	Horizontal	Horizontal
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium
9. (a)	Male sterility	-	-	-	-	-	-	-
9. (b)	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Absent	Absent	Absent	Weak	Absent	medium	Weak
11.	Lemma: anthocyanin coloration of area below apex	Absent	Absent	Absent	Absent	Weak	Medium	Weak
12.	Lemma: anthocyanin coloration of apex	Medium	Absent	Absent	Absent	Weak	Weak	Weak
13. (a)	Color of stigma	White	White	White	White	White	White	White
13. (b)	Stigma exertion	Medium	High	High	Very high	Very high	High	Medium
14.	Stem: culm diameter (from 5 mother tillers in the lowest internode)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)

Table 29. Cont'd

Sl. No.	Characteristics	Gota	Rajshahi balam	Kathi goccha	Pengek	lal-40	Ranga hogla	Gota mala
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Long (81-110)cm	Short(41-60cm)	Long (81-110)cm	Long (81-110)cm	Long (81-110)cm	Long (81-110)cm	Very Short (<40cm)
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-	-	-
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Very long	Long	Long	Long	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Weak	Weak	Strong	Strong	Strong	Medium	Weak
21.	Panicle: number of the effective tillers per plant	Many (>10)	Medium (6-10)	Medium (6-10)	Many (>10)	Many (>10)	Medium (6-10)	Medium (6-10)
22.	Spikelet: pubescence of lemma & palea	Medium	weak	Weak	Weak	weak	Medium	weak
23.	Spikelet: color of tip of lemma	Brown	Brown	Yellow	Black	Yellow	Black	Brown
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Absent	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	-	-	-	-
26. (a)	Panicle: distribution of awns	-	-	-	-	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Gota	Rajshahi balam	Kathi goccha	Pengek	lal-40	Ranga hogla	Gota mala
26. (b)	Panicle: color of a awns	-	-	-	-	-	-	-
27.	Panicle: attitude of branches	Spreading	Spreading	Spreading	Semi-erect	Semi-erect	Spreading	Spreading
28.	Panicle: exertion	Partly exerted	Partly exerted	Moderately exerted	Moderately exerted	Moderately exerted	Just exerted	Just exerted
29.	Time of maturity				Medium	Medium		
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture) (g)	28.3	25.2	23.6	26.3	20.3	28.0	15.3
31.	Grain: length (without dehulling)	Medium	Medium	Medium	Medium	Short	Medium	Short
32.	Sterile lemma length: Measure at post harvest stage	Very long	Very long	Very long	Very long	Very long	Very long	Very long
33.	Decorticated grain: length (after dehulling, before milling)	Medium	Medium	Medium	Medium	Medium	Short	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Early and fast	Early and fast	Early and fast	Early and fast	Early and fast	Early and fast	Early and fast
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Bold	Medium slender	Medium	Bold	Bold	Bold	Bold
36.	Decorticated grain (bran): color	Dark brown	White	White	Dark brown	Light brown	White	white

Table 29. Cont'd

Sl. No.	Characteristics	Gota	Rajshahi balam	Kathi goccha	Pengek	lal-40	Ranga hogla	Gota mala
37.	Polished grain: size of white core or chalkiness (% of kernel area)				-	-		
38.	Endosperm: content of amylose (Non-waxy type varieties)				-	-		
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)				-	-		

Table 29. Cont'd

Sl. No.	Characteristics	Shamba mahsuri	Lal tupi	Patnai balam	Khasrail	BINA GSR-1	BINA GSR-2	BINA GSR-3
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Dark green	Dark green	Dark green	Green	Green	Green	Purple tip
3.	Penultimate leaf pubescence	Absent	Absent	Absent	Absent	Medium	Weak	Weak
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule							
7.	Flag leaf: attitude of the blade	Horizontal	Erect	Erect	Horizontal	Semi erect	Semi erect	Semi erect

Table 29. Cont'd

Sl. No.	Characteristics	Shamba mahsuri	Lal tupi	Patnai balam	Khasrail	BINA GSR-1	BINA GSR-2	BINA GSR-3
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium	medium	medium
9. (a)	Male sterility	-	-	-	-	5	5	5
9. (b)	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Weak	Absent	Absent	Strong	Absent	Absent	Absent
11.	Lemma: anthocyanin coloration of area below apex	Weak	Absent	Absent	Strong	Absent	Absent	Absent
12.	Lemma: anthocyanin coloration of apex	Medium	Absent	Strong	Strong	Absent	Absent	Absent
13. (a)	Color of stigma	White	White	Purple	White	White	White	White
13. (b)	Stigma exertion	High	Medium	High	Medium	High	High	High
14.	Stem: culm diameter (from 5 mother tillers in the lowest internode)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)	Small (<5mm)
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Long (81-110)cm	Long (81-110)cm	Very long (>110cm)	Long (81-110)cm	Medium (61-80cm)	Medium (61-80cm)	Medium (61-80cm)
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Table 29. Cont'd

Sl. No.	Characteristics	Shamba mahsuri	Lal tupi	Patnai balam	Khasrail	BINA GSR-1	BINA GSR-2	BINA GSR-3
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-	-	-
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Long	Long	Medium	Long	Medium	Medium	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Weak	Weak	Weak	Weak	Strong	Strong	Strong
21.	Panicle: number of the effective tillers per plant	Many (>10)	Medium (6-10)	Medium (6-10)	Medium (6-10)	Medium (6-10)	Medium (6-10)	Few(<6)
22.	Spikelet: pubescence of lemma & palea	Medium	weak	Medium	Medium	Weak	Medium	Medium
23.	Spikelet: color of tip of lemma	White	Brown	Purple	Black	Yellow	White	Brown
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Absent	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	-	-	-	-
26. (a)	Panicle: distribution of awns	-	-	-	-	-	-	-
26. (b)	Panicle: color of a awn	-	-	-	-	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Shamba mahsuri	Lal tupi	Patnai balam	Khasrail	BINA GSR-1	BINA GSR-2	BINA GSR-3
27.	Panicle: attitude of branches	Erect	Semi erect	Spreading	Spreading	Spreading	Spreading	Spreading
28.	Panicle: exertion	Moderately exerted	Moderately exerted	Just exerted	Well exerted	Just	exerted	
29.	Time of maturity					Very early	Early	Early
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture) (g)	12.0	24.2	29.9	30.0	32.4	14.5	20.6
31.	Grain: length (without dehulling)	Medium	Medium	Long	Medium	Very long	Long	Medium
32.	Sterile lemma length: Measure at post harvest stage	Very long	Very Long	Very long	Very long	Very Long	Very Long	Very Long
33.	Decorticated grain: length (after dehulling, before milling)	Short	Medium	Very long	Long	Very long	Long	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Early And fast	Early and fast	Early And fast	Early And fast	Intermediate	Intermediate	Intermediate
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Round	Bold	Medium slender	Bold	Medium slender	Medium	Medium slender
36.	Decorticated grain (bran): color	White	White	White	White	Purple	White	White
37.	Polished grain: size of white core or chalkiness (% of kernel area)							

Table 29. Cont'd

Sl. No.	Characteristics	Shamba mahsuri	Lal tupi	Patnai balam	Khasrail	BINA GSR-1	BINA GSR-2	BINA GSR-3
38.	Endosperm: content of amylose (Non-waxy type varieties)							
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)							

Table 29. Cont'd

Sl. No.	Characteristics	BINA-E ₁	BINA-E ₂	BINA-E ₃	BINA AROM-8	BINA AROM-9	BINA AROM-10	Shamba Mushiri Sub-1	Chiherang Sub-1
		State	State	State	State	State	State	State	State
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Dark green	Dark green	Dark green	Green	Dark green	Green	Dark green	Green
3.	Penultimate leaf pubescence	Absent	Absent	Weak	Medium	Medium	Medium	Medium	Strong
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule	Two-cleft	Two-cleft	Two-cleft	Two-cleft	Two-cleft	Two-cleft	Two-cleft	Two-cleft
7.	Flag leaf: attitude of the blade	Erect	Erect	Semi erect	Horizontal	Semi erect	Semi erect	Erect	Semi-erect
8.	Time of heading (50% of plants with heads)	Early	Early	Early	Early	Early	Medium	Early	Very late
9.(a)	Male sterility	-	-	-	-	-	-	-	-
9.(b)	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Weak	Weak	Weak	Weak	Weak	Weak	Very weak	Weak

Table 29. Cont'd

Sl. No.	Characteristics	BINA-E ₁	BINA-E ₂	BINA-E ₃	BINA AROM-8	BINA AROM-9	BINA AROM-10	Shamba Mushiri Sub-1	Chiherang Sub-1
11.	Lemma: anthocyanin coloration of area below apex	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
12.	Lemma: anthocyanin coloration of apex	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
13. (a)	Color of stigma	White	White	White	White	White	White	White	White
13. (b)	Stigma exertion	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
14.	Stem: culm diameter (from 5 mother tillers in the lowest internode)	Small	Small	Small	Small	Small	Small	Small	Medium
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Short	Short	Short	Short	Short	Short	Short	Short
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
17.	Stem: Intensity of anthocyanin coloration of nodes	-	-	-	-	-	-	-	-
18.	Stem: anthocyanin coloration of inter-nodes	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Strong	Strong	Strong	Strong	Strong	Strong	Strong	Medium

Table 29. Cont'd

Sl. No.	Characteristics	BINA-E ₁	BINA-E ₂	BINA-E ₃	BINA AROM-8	BINA AROM-9	BINA AROM-10	Shamba Mushiri Sub-1	Chiheran g Sub-1
21.	Panicle: number of the effective tillers per plant	Many (>10)	Many(>10)	Medium (6-10)	Many(>10)	Many(>10)	Many(>10)	Many(>10)	Medium (6-10)
22.	Spikelet: pubescence of lemma & palea	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Strong
23.	Spikelet: color of tip of lemma	White	White	White	White	White	White	White	White
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	-	-	-	-	-
26. (a)	Panicle: distribution of awns	-	-	-	-	-	-	-	-
26. (b)	Panicle: color of a awns	-	-	-	-	-	-	-	-
27.	Panicle: attitude of branches	Semi-erect	Semi-erect	Semi-erect	Semi-erect	Spreading	Spreading	Semi-erect	Semi-erect
28.	Panicle: exertion	Well	Well	Well	Moderately	Moderately	Moderately	Well exerted	Moderately exerted
29.	Time of maturity	Early	Early	Early	Early	Early	Early	Medium	Very late
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture) (g)	Very high	Very high	High	High	High	High	Very high	Medium
31.	Grain: length (without dehulling)	Very long	Very long	Long	Long	Long	Long	Long	Short
32.	Sterile lemma length: Measure at post harvest stage	Very long	Very long	Very long	Very long	Very long	Very long	Medium	Medium

Table 29. Cont'd

Sl. No.	Characteristics	BINA-E ₁	BINA-E ₂	BINA-E ₃	BINA AROM-8	BINA AROM-9	BINA AROM-10	Shamba MushiriSub-1	Chiherang Sub-1
33.	Decorticated grain: length (after dehulling, before milling)	Long	Long	Long	Long	Long	Long	Long	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Early and fast	Early and fast	Late and slow	Late and slow	Intermediate	Intermediate	Late and slow	Late and slow
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Medium slender	Medium slender	Medium slender	Medium slender	Medium slender	Medium slender	Medium slender	Medium slender
36.	Decorticated grain (bran): color	White	White	White	White	White	White	White	White
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-	-	-	-
38.	Endosperm: content of amylose (Non-waxy type varieties)	-	-	-	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)	-	-	-	-	-	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Chengri	Horti-1	Kaloborgi (Black)	Kaloborgi (White)	Kasalat
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Green	Green	Green	Green	Green
3.	Penultimate leaf pubescence	Weak	Weak	Weak	Weak	Weak

Table 29. Cont'd

Sl. No.	Characteristics	Chengri	Horti-1	Kaloborgi (Black)	Kaloborgi (White)	Kasalat
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule	Two-cleft	Two-cleft	Two-cleft	Two-cleft	Two-cleft
7.	Flag leaf: attitude of the blade	Semi-erect	Erect	Semi-erect	Semi-erect	Semi-erect
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium
9.a	Male sterility	-	-	-	-	-
9.b	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Weak	Weak	Weak	Weak	Weak
11.	Lemma: anthocyanin coloration of area below apex	Weak	Weak	Weak	Weak	Weak
12.	Lemma: anthocyanin coloration of apex	Weak	Weak	Weak	Weak	Weak
13.a	Color of stigma	White	White	White	White	White
13.b	Stigma exertion	High	Medium	High	High	High
14.	Stem: culm diameter(from 5 mother tillers in the lowest internode)	Medium	Medium	Medium	Medium	Medium
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Medium	Medium	Short	Medium	Medium

Table 29. Cont'd

Sl. No.	Characteristics	Chengri	Horti-1	Kaloborgi (Black)	Kaloborgi (White)	Kasalat
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent
17.	Stem: Intensity of anthocyanin coloration of nodes	Weak	Weak	Weak	Weak	Weak
18.	Stem: anthocyanin coloration of inter-nodes	Weak	Weak	Weak	Weak	Weak
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Medium	Medium	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Medium	Medium	Medium	Medium	Medium
21.	Panicle: number of the effective tillers per plant	Medium	Medium	Medium	Medium	Medium
22.	Spikelet: pubescence of lemma & palea	Absent	Absent	Absent	Absent	Absent
23.	Spikelet: color of tip of lemma	White	White	White	White	White
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Absent
25.	Spikelet: length of the longest awn	-	-	-	-	-
26.a	Panicle: distribution of awns	-	-	-	-	-
26.b	Panicle: color of a awns	-	-	-	-	-
27.	Panicle: attitude of branches	Semi erect	Erect	Erect	Semi erect	Semi erect
28.	Panicle: exertion	Moderate exerted	Moderate exerted	Moderate exerted	Moderate exerted	Moderate exerted

Table 29. Cont'd

Sl. No.	Characteristics	Chengri	Horti-1	Kaloborgi (Black)	Kaloborgi (White)	Kasalat
29.	Time of maturity	Medium	Medium	Medium	Medium	Medium
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture)	Medium	Medium	Medium	Medium	Medium
31.	Grain: length (without dehulling)	Medium	Medium	Medium	Medium	Medium
32.	Sterile lemma length: Measure at post harvest stage	-	-	-	-	-
33.	Decorticated grain: length (after dehulling, before milling)	Medium	Medium	Medium	Medium	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	Late and slow	Late and slow	Late and slow	Late and slow	Late and slow
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	Medium	Medium slender	Medium	Medium	Medium
36.	Decorticated grain (bran): color	Brown	Light brown	Brown	Light brown	Light brown
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-
38.	Endosperm: content of amylose (Non-waxy type varieties)	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)	-	-	-	-	-

Table 29. Cont'd

Sl. No.	Characteristics	Impari	Impago	P6DBNC	Dhumai	Baurash
1.	Leaf sheath: anthocyanin color	Absent	Absent	Absent	Absent	Absent
2.	Leaf color	Green	Green	Green	Dark Green	Green
3.	Penultimate leaf pubescence	Weak	Weak	Weak	Weak	Weak
4.	Penultimate leaf: anthocyanin coloration of auricles & collar	Absent	Absent	Absent	Absent	Absent
5.	Penultimate leaf: ligule	Present	Present	Present	Present	Present
6.	Penultimate leaf: shape of the ligule	Two-cleft	Two-cleft	Two-cleft	Two-cleft	Two-cleft
7.	Flag leaf: attitude of the blade	Semi-erect	Semi-erect	Semi-erect	Semi-erect	Semi-erect
8.	Time of heading (50% of plants with heads)	Medium	Medium	Medium	Medium	Medium
9.a	Male sterility	-	-	-	-	-
9.b	Microscopic observation of pollen with I ₂ -KI solution	-	-	-	-	-
10.	Lemma & Palea: anthocyanin coloration	Weak	Weak	Weak	Weak	Weak
11.	Lemma: anthocyanin coloration of area below apex	Weak	Weak	Weak	Weak	Weak
12.	Lemma: anthocyanin coloration of apex	Weak	Weak	Weak	Weak	Weak
13.a	Color of stigma	White	White	White	White	White
13.b	Stigma exertion	High	High	High	High	High

Table 29. Cont'd

Sl. No.	Characteristics	Impari	Impago	P6DBNC	Dhumai	Baurash
14.	Stem: culm diameter(from 5 mother tillers in the lowest internode)	Medium	Medium	Medium	Medium	Medium
15.	Stem length (Culm length): Measure from the base of the plants to the neck of the panicles)	Medium	Medium	Medium	Short	Medium
16.	Stem: anthocyanin coloration of nodes	Absent	Absent	Absent	Absent	Absent
17.	Stem: Intensity of anthocyanin coloration of nodes	Weak	Weak	Weak	Weak	Weak
18.	Stem: anthocyanin coloration of inter-nodes	Weak	Weak	Weak	Weak	Weak
19.	Panicle length: measured from the neck to the tip of the panicle of main tillers without awns	Medium	Medium	Medium	Medium	Medium
20.	Panicle: curvature of main axis (i.e., recurved main axis)	Medium	Medium	Medium	Medium	Medium
21.	Panicle: number of the effective tillers per plant	Medium	Medium	Medium	Many	Many
22.	Spikelet: pubescence of lemma & palea	Absent	Absent	Absent	Absent	Absent
23.	Spikelet: color of tip of lemma	White	White	White	Black	Black
24.	Spikelet: awns in the spikelet	Absent	Absent	Absent	Absent	Absent

Table 29. Cont'd

Sl. No.	Characteristics	Impari	Impago	P6DBNC	Dhumai	Baurash
25.	Spikelet: length of the longest awn	-	-	-	-	-
26.a	Panicle: distribution of awns	-	-	-	-	-
26.b	Panicle: color of a awns	-	-	-	-	-
27.	Panicle: attitude of branches	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect
28.	Panicle: exertion	Moderate exerted	Moderate exerted	Moderate exerted	Moderate exerted	Moderate exerted
29.	Time of maturity	Medium	Medium	Medium	Medium	Medium
30.	Grain: weight of 1000 fully developed grains (adjusted at 12% of moisture)	Medium	Medium	Medium	Medium	Medium
31.	Grain: length (without dehulling)	Medium	Medium	Medium	Medium	Medium
32.	Sterile lemma length: Measure at post harvest stage	-	-	-	-	-
33.	Decorticated grain: length (after dehulling, before milling)	Medium	Medium	Medium	Medium	Medium
34.	Leaf senescence: Penultimate leaves are observed at the time of harvest	-	-	-	-	-
35.	Decorticated grain: shape (Length-width (widest point) ratio of de-hulled grain)	-	-	-	-	-
36.	Decorticated grain (bran): color	Light brown	Light brown	Brown	Light brown	Light brown

Table 29. Cont'd

Sl. No.	Characteristics	Impari	Impago	P6DBNC	Dhumai	Baurash
37.	Polished grain: size of white core or chalkiness (% of kernel area)	-	-	-	-	-
38.	Endosperm: content of amylose (Non-waxy type varieties)	-	-	-	-	-
39.	Decorticated grain: aroma	Absent	Absent	Absent	Absent	Absent
40.	Other distinct special character (if any)					



Leaf



Ligule



Panicle



Floret



Seed



Root

IRATOM-24

Fig. 41. Photograph showing different parts of rice varieties and germplasm



Leaf



Ligule



Panicle



Floret



Seed



Root

Binadhan-5



Ligule



Leaf



Panicle



Floret



Seed



Root

Binadhan-6

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Binadhan-7



Leaf



Ligule



Panicle



Floret



Seed



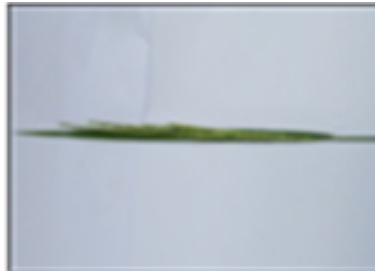
Root

Binadhan-8

Fig. 41. Cont'd



Leaf



Panicle



Floret



Seed



Root

Binadhan-10



Leaf



Ligule



Panicle



Floret



Seed

Bina-E-1

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Bina-E-2



Leaf



Ligule



Panicle



Floret



Seed

Bina-E-3

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Bina-GSR-1



Leaf



Ligule



Panicle



Floret



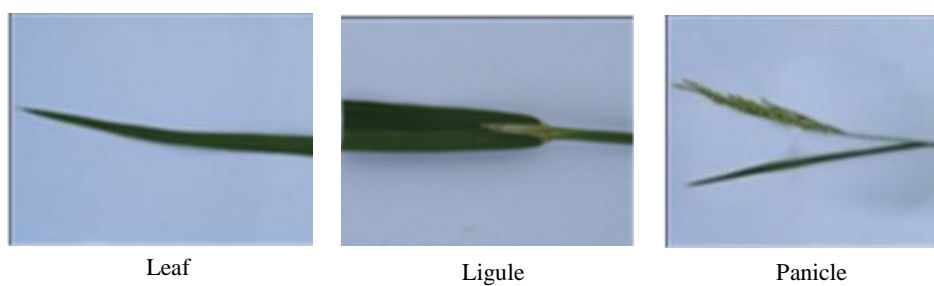
Seed

Bina-GSR-2

Fig. 41. Cont'd

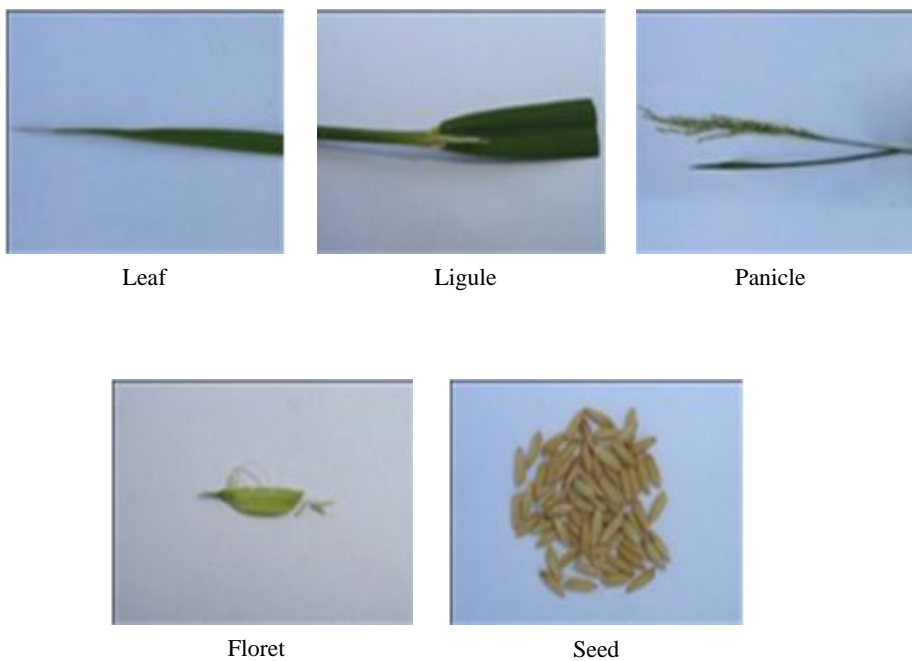


Bina-GSR-3

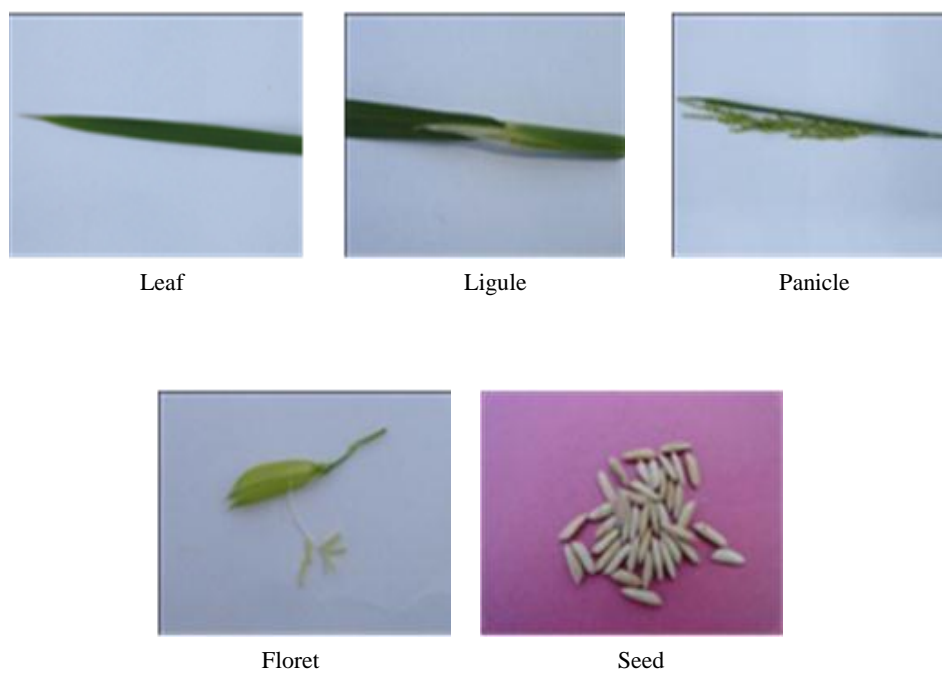


Bina Arom-8

Fig. 41. Cont'd



Bina Arom-9



Bina Arom-10

Fig. 41. Cont'd



Tal Mugur



Tor Balam

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Jolkumri



Leaf



Ligule



Panicle



Floret



Seed

Ponkhiraj

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Shorna mahsuri



Leaf



Ligule



Panicle



Floret



Seed

Vashiara

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Machraga



Leaf



Ligule



Panicle



Floret



Seed

Gota

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Rajshaibala



Leaf



Ligule



Panicle



Floret



Seed

Kathgoccha

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Ranga-Hogla



Leaf



Ligule



Panicle



Floret



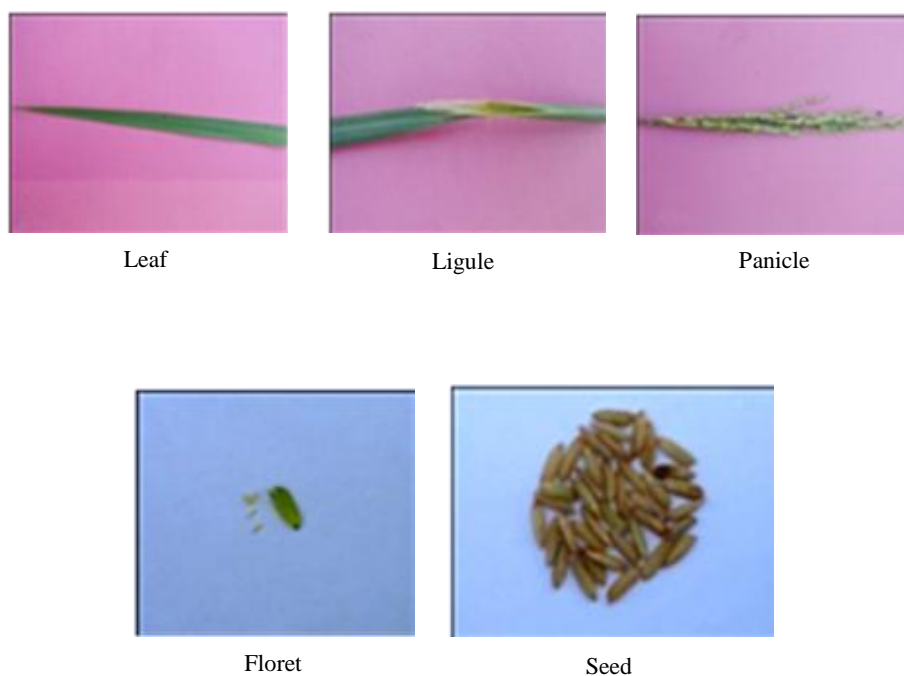
Seed

Hamai

Fig. 41. Cont'd

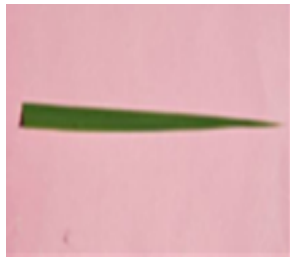


Lal Tupi



Patnai Balam

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Kherail



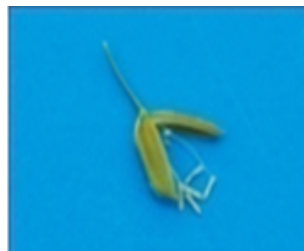
Leaf



Ligule



Panicle



Floret



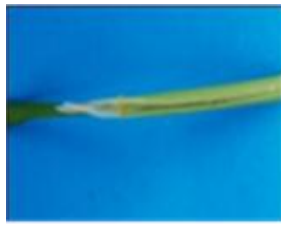
Seed

Kajol shail

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Hogla



Leaf



Ligule



Panicle



Floret



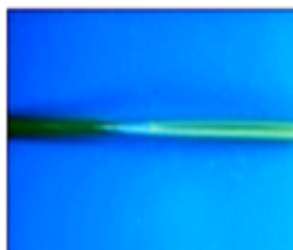
Seed

Pengek

Fig. 41. Cont'd



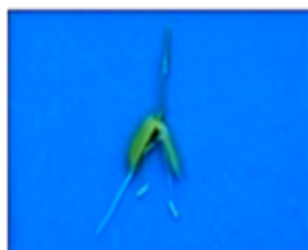
Leaf



Ligule



Panicle



Floret



Seed

Jamai Naru



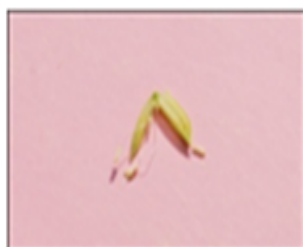
Leaf



Ligule



Panicle



Floret



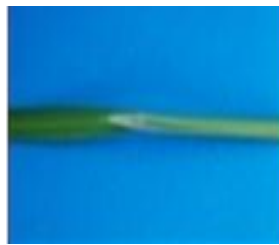
Seed

Lal-40

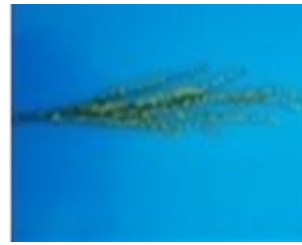
Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Dhakshail



Leaf



Ligule



Panicle



Floret



Seed

Bhute shalot

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Khak shail



Leaf



Ligule



Panicle



Floret



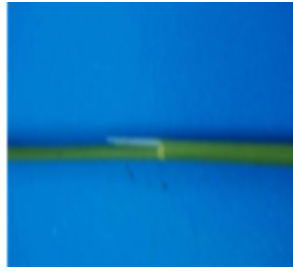
Seed

Mohime

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Hati Bajore



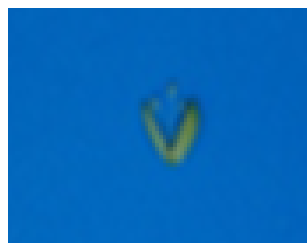
Leaf



Ligule



Panicle



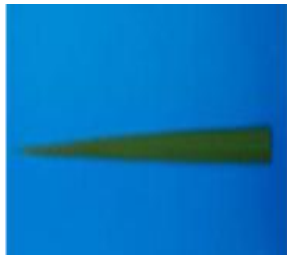
Floret



Seed

Malagoti

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Patnai



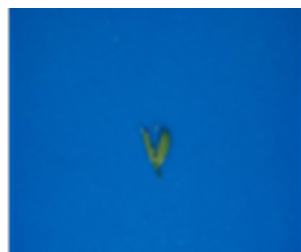
Leaf



Ligule



Panicle



Floret



Seed

Kute patnai

Fig. 41. Cont'd



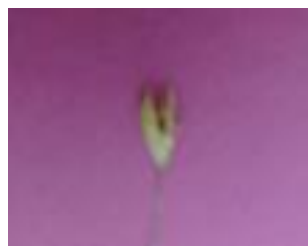
Leaf



Ligule



Panicle



Floret



Seed

Bazra muri



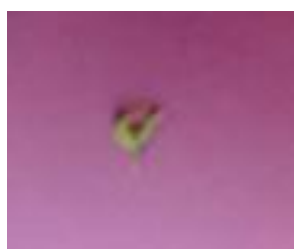
Leaf



Ligule



Panicle



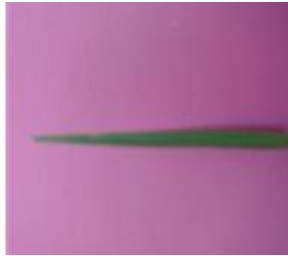
Floret



Seed

Ghunshi

Fig. 41. Cont'd



Leaf



Ligule



Panicle



Floret



Seed

Lalgotal



Floret



Panicle



Leaf



Ligule



Seed

Mondeshor

Fig. 41. Cont'd



Floret

Panicle

Leaf

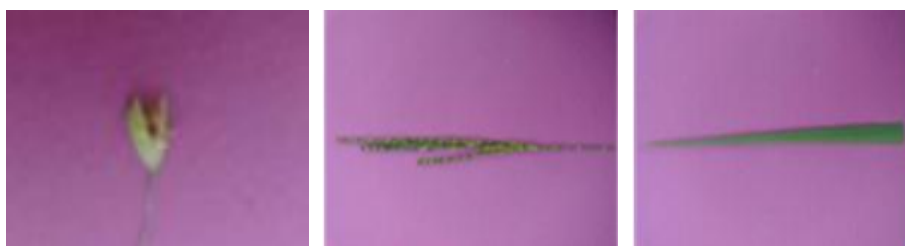


Ligule



Seed

NDNAkochi



Floret

Panicle

Leaf



Ligule



Seed

Jotabalam

Fig. 41. Cont'd



Floret

Panicle

Leaf



Ligule



Seed

Kalomota



Floret

Panicle

Leaf



Ligule



Seed

Hode gotal

Fig. 41. Cont'd



Floret

Panicle

Leaf



Ligule

Seed

Karengal



Floret

Panicle

Leaf

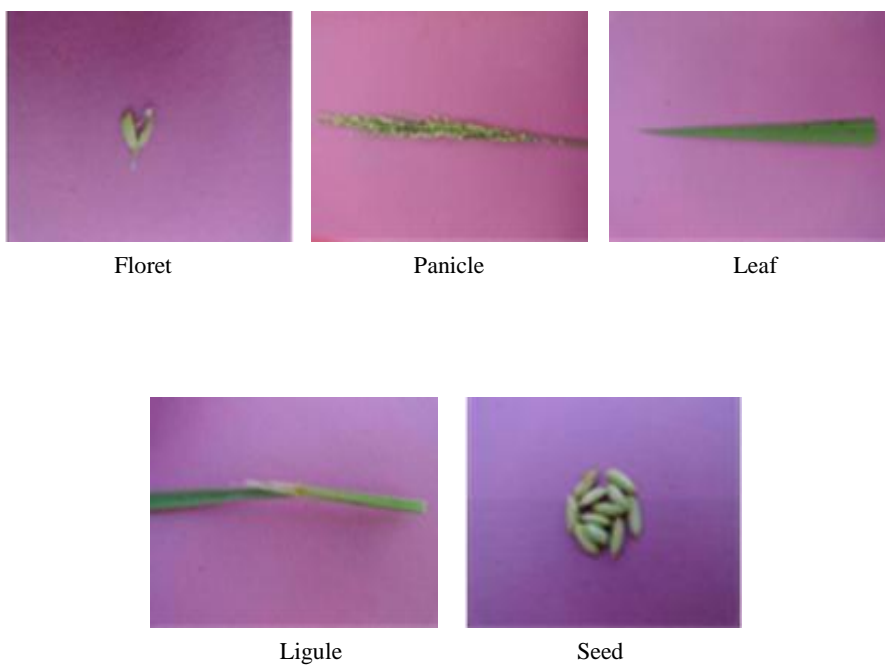


Ligule

Seed

Hogla

Fig. 41. Cont'd

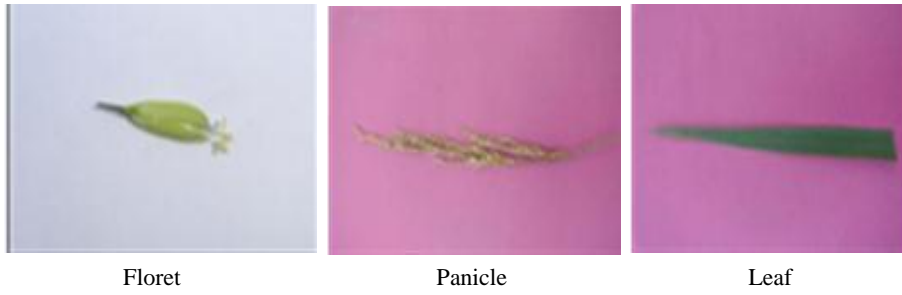


Dhudshail



Samba Mahsuri-sub1

Fig. 41. Cont'd

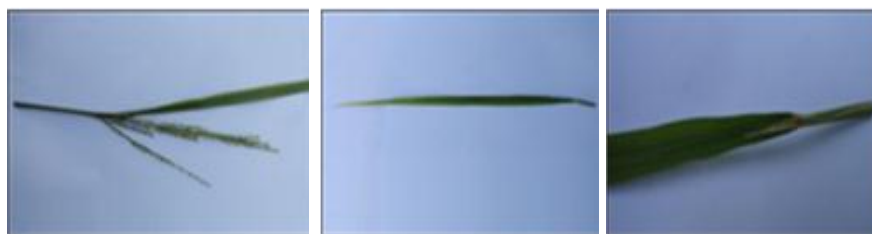


Ciherang-sub1



Gotamala

Fig. 41. Cont'd



Panicle

Leaf

Ligule



Seed



Root

Chegri



Panicle

Leaf

Ligule



Seed



Root

Binadhan-5

Fig. 41. Cont'd



Panicle

Leaf

Ligule



Seed



Root

Impari



Panicle

Leaf

Ligule



Seed



Root

Kaloborgi (Black)

Fig. 41. Cont'd



Panicle



Leaf



Ligule



Seed



Root

Kasalot



Panicle



Leaf



Ligule



Seed



Root

P6DBNC

Fig. 41. Cont'd



Panicle



Leaf



Ligule



Seed



Root

Dhumai



Panicle



Leaf



Ligule



Seed



Root

Baurash

Fig. 41. Cont'd



Panicle

Leaf

Ligule



Seed



Root

Kaloborgi (White



Panicle

Leaf

Ligule



Seed



Root

Horti-1

Fig. 41. Cont'd

Molecular Characterization of Rice varieties/germplasm

The experiments were conducted at the Biotechnology Laboratory of Biotechnology Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Eight rice varieties (instead of 7) and 50 germplasm (out of 60) were characterized using RAPD/SSR markers.

Characterization of four rice germplasm through RAPD markers

Primer selection and RAPD pattern

Ten primers were initially screened on four germplasm (BINA E-1, BINA E-2 BINA E-3 and Binadhan-7) for their ability to produce polymorphic patterns and 4 primers viz. OPB01, OPB02, OPC01 and OPC05 which gave reproducible and distinct polymorphic amplified products were selected. A total of 36 RAPD bands were scored of which 31 (86.24%) polymorphic amplification products were obtained by using these arbitrary primers. The size of the amplification size ranged from 100-2072 bp (Table 30). The selected 4 primers produced comparatively maximum number of high intensity band with minimal smearing, good technical resolution and sufficient variation among different cultivars. The dissimilar numbers of bands were generated by primer OPB01, OPB02, OPC01 and OPC05. Other germplasm were not genotypes due to unavailability of the primers.

Table 30. RAPD primers with corresponding bands score and their size range together with polymorphic bands observed in 4 rice germplasm

Primer code	Sequences (5'-3')	Number of bands scored	Size ranged (bp)	Number of polymorphic bands	Polymorphic loci (%)
OPB01	GTTTCGCTCC	10	100-2072	10	100.00
OPB02	TGCCGAGCTG	9	100-2072	8	88.89
OPC01	TTCGAGCCAG	11	100-2072	8	72.73
OPC05	GATGACCGCC	6	100-2072	5	83.33
Total		36		31	344.95
Average		9.0		7.75	86.24

Besides, the primer OPB01 amplified maximum number of polymorphic bands (100%) while the primer OPC01 generated the least (72.73%) polymorphic bands which were minimal in number. The banding patterns of 4 germplasm using primers OPB01, OPB02, OPC01 and OPC05 are shown in Fig. 42-45.

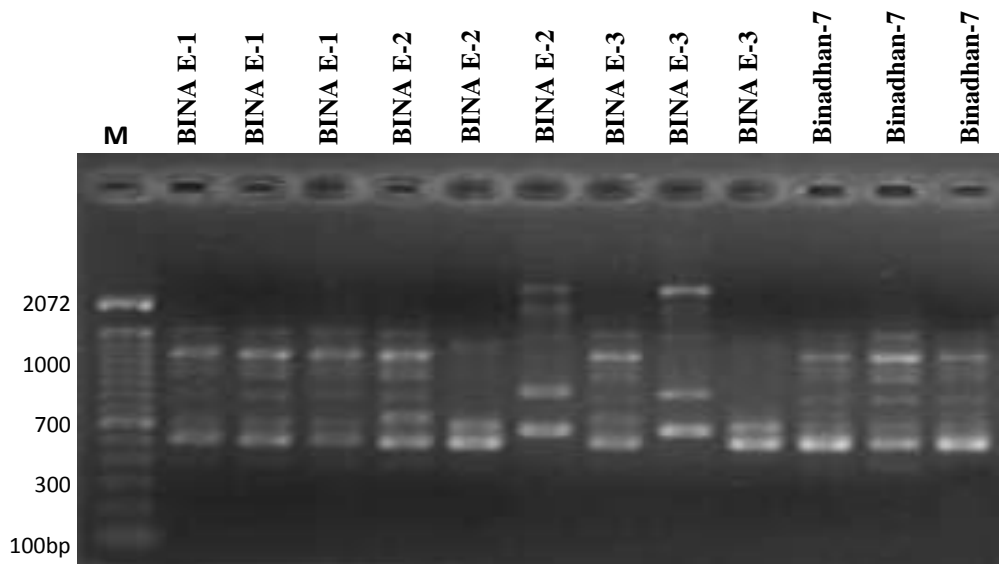


Fig. 42. RAPD profiles of different 4 rice germplasm using primer OPB01. (M): 100 bp DNA ladder

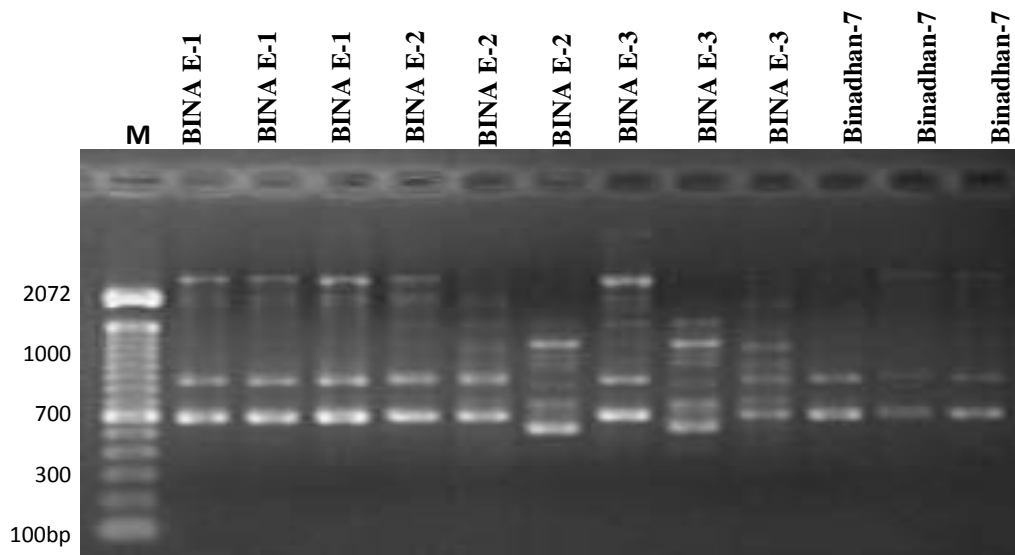


Fig. 43. RAPD profiles of different 4 rice germplasm using primer OPB02. (M): 100 bp ladder

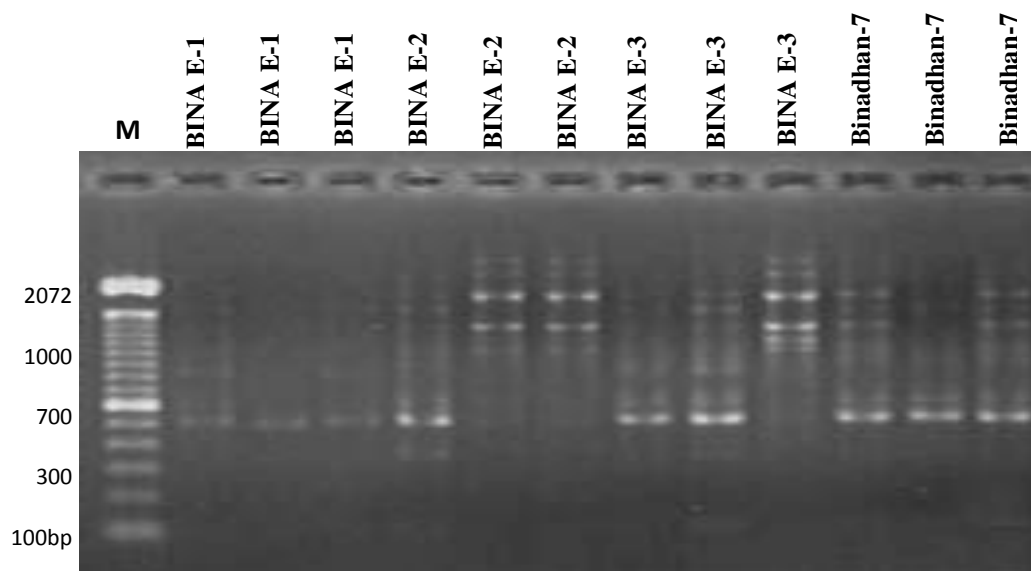


Fig. 44. RAPD profiles of different 4 rice germplasm using primer OPC01. (M): 100 bp DNA ladder

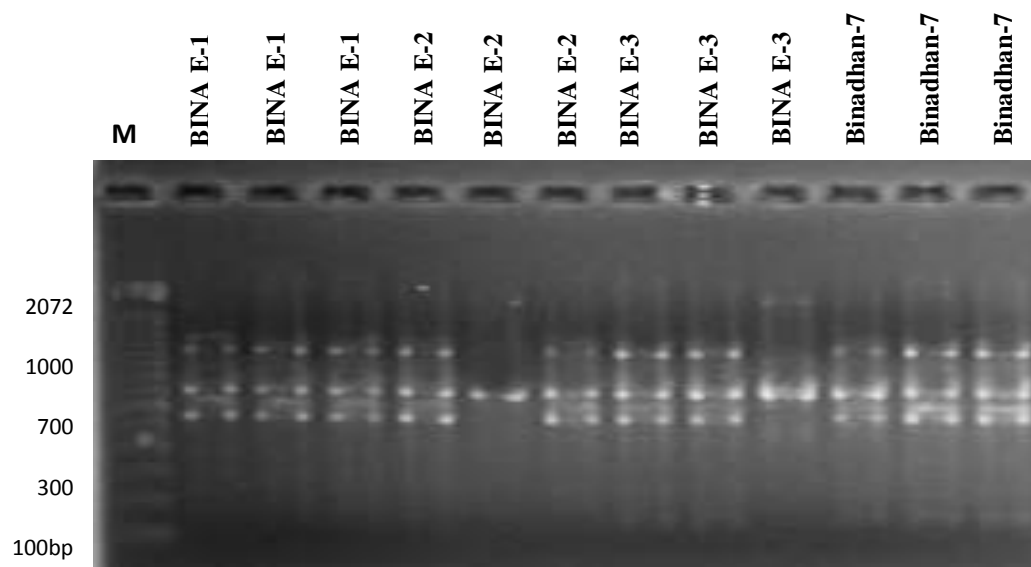


Fig. 45. RAPD profiles of different 4 rice germplasm using primer OPC05. (M): 100 bp DNA ladder

Polymorphism and Nei's gene diversity

The highest proportion of polymorphic loci 75.00% was found in BINA-E-3 which gave 27 polymorphic bands and the lowest proportion of polymorphic loci 11.11% was found in BINA E-1 and Binadhan-7, showed 4 polymorphic bands (Table 31).

BINA-E-3 showed the higher level of gene diversity 0.3032 than other genotypes. Gene diversity across all genotypes for all loci was 0.6826. Binadhan-7 showed the lowest 0.0438 gene diversity. Shannon's Information index (I) of all rice genotypes was 0.9932. BINA E-3 showed the highest 'I' value 0.4427 and Binadhan-7 showed the lowest 0.0643, respectively. Since BINA E-3 exhibited higher percentage of Polymorphic loci, gene diversity and Shannon's Information index suggested higher polymorphism.

Table 31. Estimates of genetic variation, Percentage of polymorphic loci. Nei's gene diversity and Shannon's Information index (I) obtained from 4 rice germplasm

Genotypes	No. of polymorphic loci	Proportion of polymorphic loci (%)	Gene diversity	Shannon's Information index (I)
BINA E-1	4	11.11	0.0542	0.0757
BINA E-2	25	69.44	0.2814	0.4105
BINA E-3	27	75.00	0.3032	0.4427
Binadhan-7	4	11.11	0.0438	0.0643
Total			0.6826	0.9932

Gene diversity for the RAPD primer

Average gene diversity (h) and Shannon's information index (I) across all primer against genotypes for all loci was found 0.3033 and 0.4556. High level of gene diversity value and Shannon's information index was found in locus OPB02-4 (0.5000 and 0.6931, respectively). Lowest level of gene diversity value and Shannon's information index (0.0000 and 0.0000) was found in locus OPB02-6, OPC01-4, OPC01-10 and OPC05-4.

Genetic distance

The values of pair-wise comparisons of Nei's (1972) genetic distance among 4 rice genotypes were computed from combined data sets for the four primers ranging from 0.0554 to 0.4152 (Table 32). Comparatively higher genetic distance 0.4152 was found between BINA E-2 and Binadhan-7. The lowest genetic distance 0.0554 was revealed between BINA E-2 and BINA E-3.

Table 32. Summary of Nei's (1972) genetic distance (below diagDNAI) and genetic identity (above diagDNAI) values among 4 rice germplasm

Genotypes	BINA E-1	BINA E-2	BINA E-3	Binadhan-7
BINA E-1	****	0.7172	0.7879	0.8993
BINA E-2	0.3324	****	0.9461	0.6602
BINA E-3	0.2383	0.0554	****	0.7498
Binadhan-7	0.1062	0.4152	0.2880	****

UPGMA Dendrogram

A dendrogram was constructed based on Nei's (1972) genetic distance following the Unweighted Pair Group Method of Arithmetic Means (UPGMA). The 4 genotypes of rice were grouped into 2 main clusters (Fig. 46). Genotypes BINA E-1 and Binadhan-7 were included in first cluster while were BINA E-2 and BINA E-3 genotypes in the second Cluster. Genetic relationship was present between two clusters. Genotypic variations based on molecular characterization indicated that genotypes belonging to different clusters depend on their genetic components itself, but not at geographical origin at all. Therefore, it could be concluded that for further research program, especially for hybridization, genotype could be selected from different clusters will be provided maximum heterosis regarding yield. Rana *et al.* (2007) observed UPGMA cluster analysis for the combined data of RAPD and STMS revealed two broad clusters (Fig. 46).

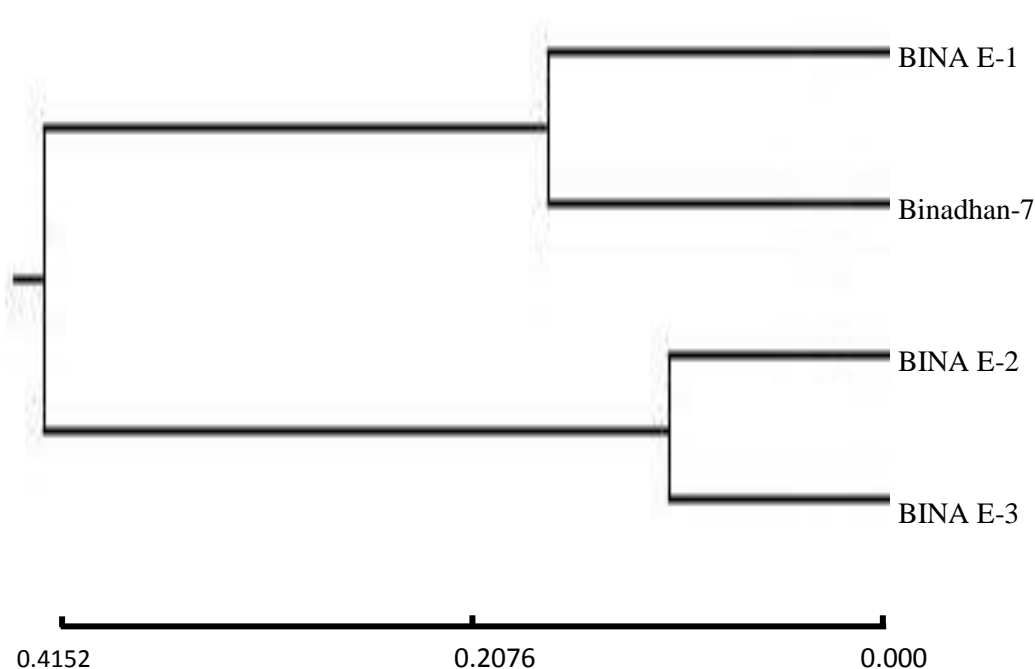


Fig.46. UPGMA dendrogram based on Nei's (1972) genetic distance summarizing the data on differentiation between 4 rice germplasm, according to RAPD analysis

Molecular characterization of 25 landraces using SSR markers

Primer selection and SSR of four rice germplasm

Twenty five rice germplasm were used for molecular characterization. Six SSR primer pairs (RM585, RM510, RM336, RM515, RM351 and RM234) were used for primer selection. Among these, RM585, RM510 and RM336 were selected for final analysis. Amplified microsatellite loci were analyzed for polymorphism using agarose gel electrophoresis and then finally by polyacrylamide gel electrophoresis. Microsatellite profiles of 25 rice germplasms at loci RM585, RM510, RM336 were shown in Fig. 47-49. The result revealed that all the primer pairs detected polymorphism among the rice genotypes analyzed. The microsatellite loci were also multiallelic (ten to twelve alleles per locus with a mean of eleven/locus in the present study).

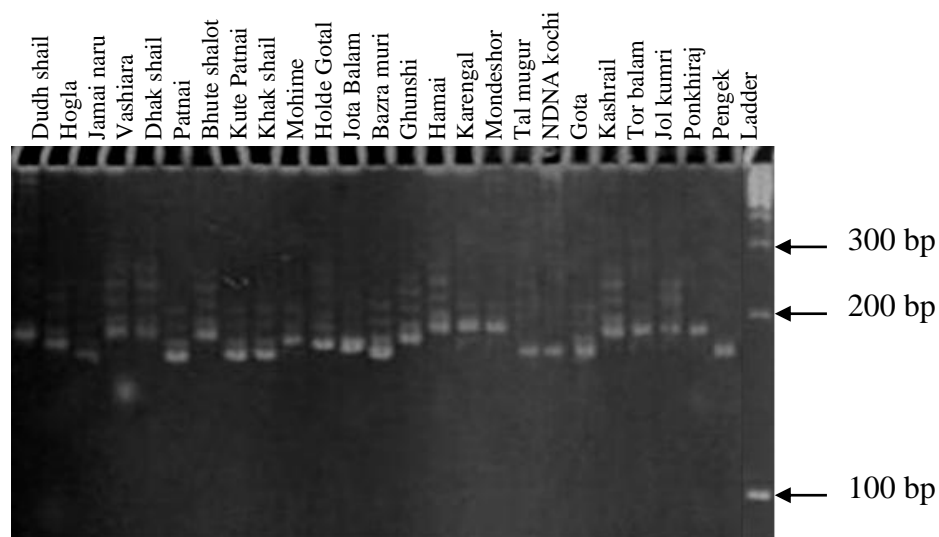


Fig. 47. Microsatellite profiles of 25 rice germplasm at loci RM585 (Ladder = 100bp)

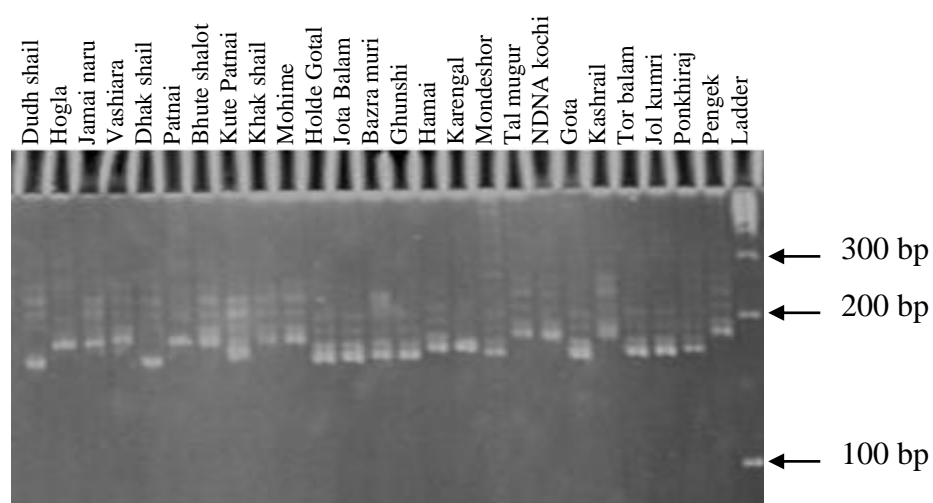


Fig. 48. Microsatellite profiles of 25 rice germplasm at loci RM510 (Ladder= 100bp)

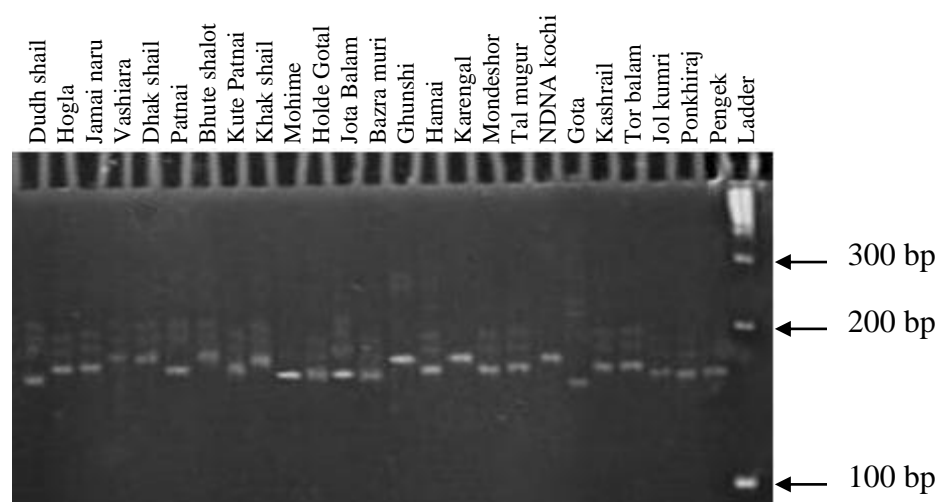


Fig. 49. Microsatellite profiles of 25 rice germplasm at loci RM336 (Ladder= 100bp)

Size and Frequency of Alleles

In respect of primer 510, allele size ranged from 165bp - 199bp, whereas primer 336 showed a range 159bp - 182bp and primer 585 gave a range from 178bp to 205bp (Table 33).

Number of Alleles per Locus

Using 3 SSR markers, a total of 33 alleles were detected among the 25 rice germplasm. The average number of allele per locus was 11, with a range of 10 (RM336) to as many as 12 (RM510) (Table 33). Comparing microsatellite markers with the different repeat motifs, those with GA repeats had the largest number of alleles (12). Nearly similar observation was found by Dhar *et al.*, (2007), where they got that average number of allele per locus was 10, with a range of 8 (RM152) to as many as 12 (RM7075 & RM10701) among the 26 rice germplasms by using 6 SSR markers.

Table 33. Data on allele size, number of alleles, PIC value and gene diversity (GD) among 25 rice germplasm for 3 microsatellites (SSR)

Locus	Allele Size ranges(bp)	Difference (bp)	No. of alleles	PIC	Gene Diversity
RM510	165-199	34	12	0.8869	0.8960
RM336	159-182	23	10	0.8533	0.8672
RM585	178-205	27	11	0.8940	0.9024
Mean	----	----	11	0.8781	0.8885

Gene Diversity

According to Nei's, (1983), the highest level of gene diversity value (0.9024) was observed in loci RM585 and the lowest level of gene diversity value (0.8672) was observed in loci RM336 with a mean diversity of 0.8885 (Table 31). It was observed that marker detecting the lower number of alleles showed lower gene diversity than those which detected higher number of alleles which revealed higher gene diversity. The other primer showed a gene diversity value of 0.8960. The maximum number of repeats within the SSRs was also positively correlated with the genetic diversity. This result is consistent with previous work done by Heenan *et al.* (2000), who observed that the gene diversity at each SSR locus was significantly correlated with the number of alleles detected, number of repeat motif and with the allele size range. Dhar *et al.* (2012) observed that the highest level of gene diversity value (0.8994) was observed in loci RM10701 and the lowest level of gene diversity value (0.7743) was observed in loci RM152 with a mean diversity of 0.8544.

PIC (Polymorphism Information Content) values

As a measure of the informative nature of microsatellites, the PIC values ranged from a low of 0.8533 (RM336) to a high of 0.8940 (RM585) and averaged 0.8781 (Table 34). The third primer showed a PIC value of 0.8869. PIC values also showed a significant, positive correlation with the number of alleles and allele size range for microsatellites evaluated in this study. The allele size range and the number of alleles were themselves also highly correlated. PIC values ranged from a low of 0.7459 (RM152) to a high of 0.8908 (RM10701) and averaged 0.857 was observed by Dhar *et al.* (2012).

Table 34. Data on repeat motif, number of alleles, number of rare alleles, PIC value and gene diversity (GD) found among 25 rice genotypes for 3 microsatellites (SSR)

Locus	Repeat Motif	Allele Size ranges(bp)	Difference (bp)	No. of alleles	Rare alleles	PIC	Gene Diversity
RM510	(GA)15	165-199	34	12	4	0.8869	0.8960
RM336	(CTT)18	159-182	23	10	3	0.8533	0.8672
RM585	(TC)45	178-205	27	11	1	0.8940	0.9024
Mean	-----	----	----	11	2.667	0.8781	0.8885

Molecular characterization of 20 landraces using RAPD markers

Primer selection and RAPD pattern

Eight primers were initially screened for their ability to produce polymorphic patterns and out of 8, three primers viz. OPA05, OPB06 and OPA02 gave reproducible and distinct polymorphic amplified products.

Selected three primers generated 22 bands. Out of the 22 bands, 16 bands (72.73%) were polymorphic and 6 bands (27.27%) were monomorphic (Table 35). This proportion of polymorphism was similar compared to previous RAPD analysis in rice germplasm by Qian *et al.* (2006) who obtained 83.5% of polymorphic products.

The three different primers generated various banding patterns, ranging from 5 (OPA02) to 10 (OPA05). The primer OPB06 and OPA02 produced the lower numbers (4) and (3) of polymorphic bands, respectively. The primer OPA05 produced higher level of polymorphism.

Table 35. RAPD primers with corresponding polymorphic bands scored in rice germplasm

Primer codes	Sequences (5'-3')	No. of bands	No. of polymorphic bands	Polymorphic loci (%)
OPA05	AGGGGTCTTG	10	9	72.73%
OPB06	TGCTCTGCCC	7	4	
OPA02	TGCCGAGCTG	5	3	
Total		22	16	

The primer OPA05 not only produced maximum number of total bands (10) but also amplified maximum number of polymorphic bands (9). On the other hand, the primer OPA02 amplified lower number (3) of polymorphic bands.

A diverse levels of polymorphism in rice germplasm were reported by Tang *et al.* (2002), 95.33%, Ravi *et al.* (2003), 90%, Valdmarr *et al.* (2004), 72.2%, Vibha *et al.* (2005), 94.36%, Qian *et al.* (2006), 83.5%, Shivapriya *et al.* (2006) 74.1%.

The banding patterns of different rice germplasm using primers OPA05, OPB06 and OPA02 are shown in Fig. 50-52.

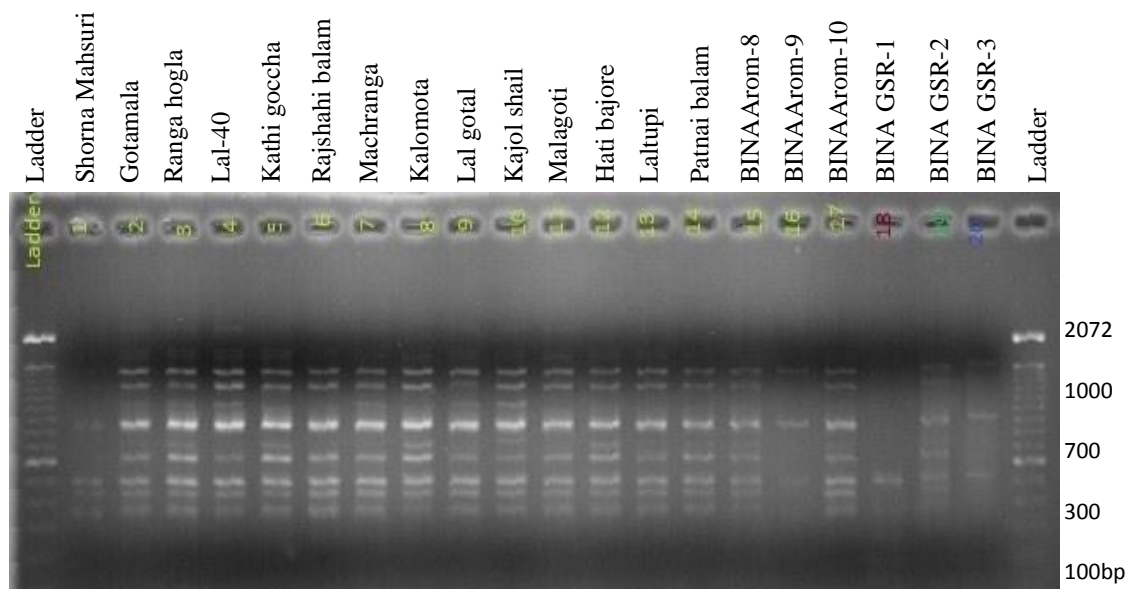


Fig. 50. RAPD profiles of 20 rice germplasm using primer OPA05

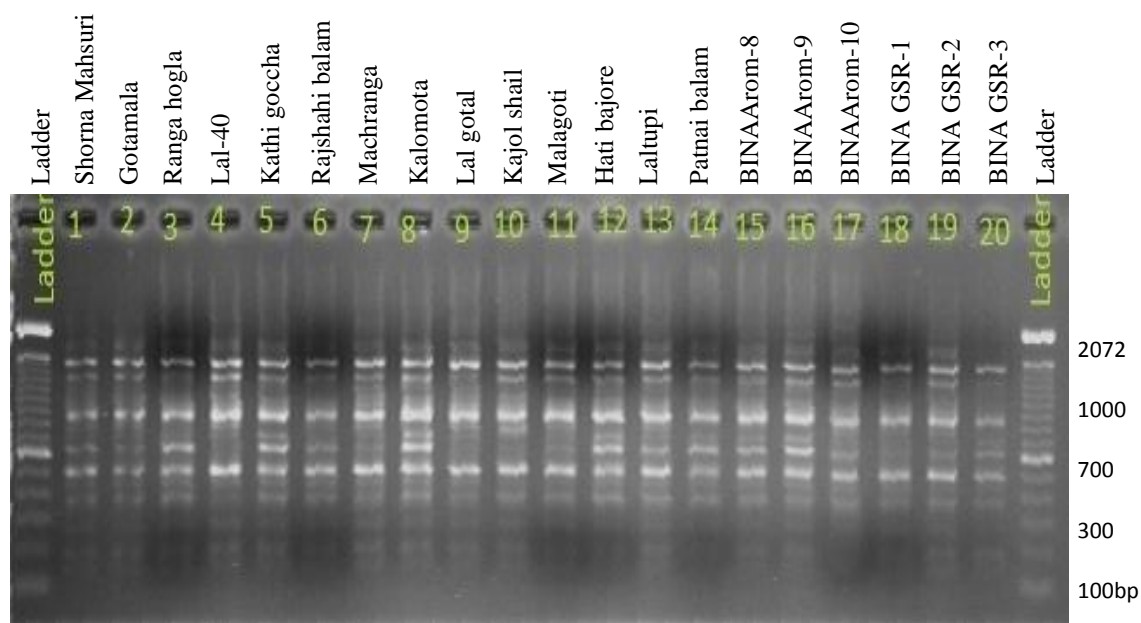


Fig. 51. RAPD profiles of 20 rice germplasm using primer OPB06

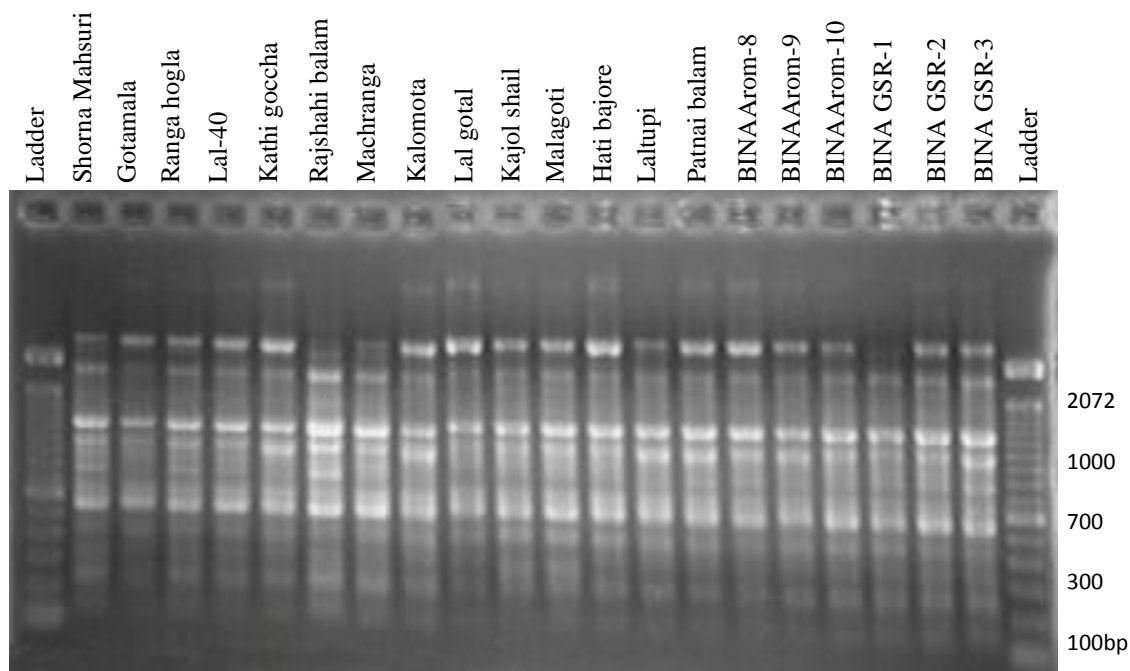


Fig. 52. RAPD profiles of 20 rice germplasm using primer OPA02

Molecular Characterization of 2 rice germplasm and 8 rice varieties

Banding pattern of 2 rice germplasm using RAPD marker is shown in Fig. 53.

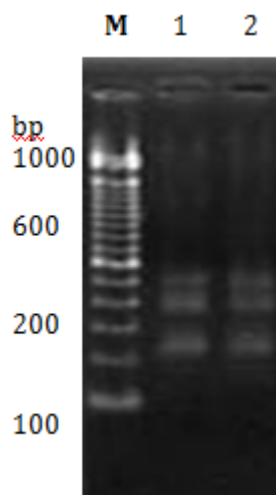


Fig. 53. RAPD profile of 2 rice germplasm using primer OPF12

Banding pattern of 8 rice varieties using SSR marker is shown in Fig. 54.

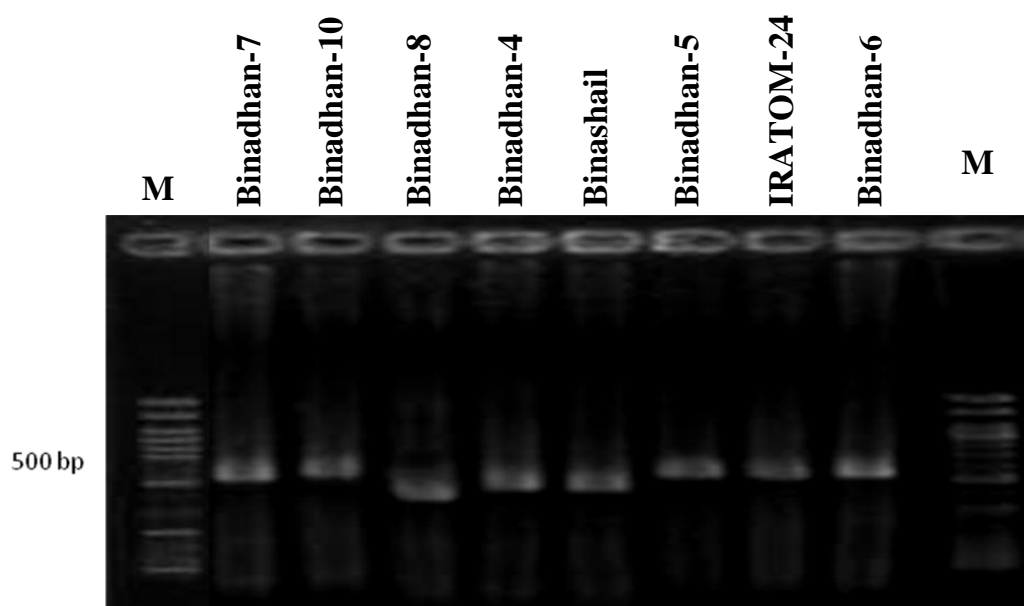


Fig. 54. Microsatellite profile of 8 rice germplasm at loci RM11757

Crop: Lentil (*Lens esculenta*)

Six lentil varieties along with 22 germplasm (instead of 20) were put into an experimental trial at Mymensingh Head Quarter farm during Rabi season, 2011-12. The experiment was carried out in a randomized complete block design with three replications. Unit plot was 2 m x 3 m. Distances between rows and plants were 30 cm and 5-6 cm, respectively. Data was recorded according to descriptor of IBPGR/IPGRI and photograph was taken. Data and photograph are presented in Table 36 & 37 and Fig. 56 & 57.

Table 36. Distinctness of the morphological characters of lentil varieties

Varieties	Seedling stem pigmentation	Leaflet size	Plant height (cm)	Days to flowering	Days to maturity	No. of primary branches/plant	No. of secondary branches/plant
Binamasur-1	Present	Small	42	40-45	125	3.9	10.8
Binamasur-2	Absent	Small	34	35-40	98	3.0	11.8
Binamasur-3	Present	Small	34	36-40	95	3.2	10.0
Binamasur-4	Absent	Small	35	34-38	96	3.4	12.8
Binamasur-5	Absent	Small	37	35-40	99	3.3	11.4
Binamasur-6	Absent	Small	33	38-44	105	3.6	10.8

Table 36. Cont'd

Varieties	Tendrill length	Flower ground colour	Pod pigmentation	Ground colour of testa	Pattern of testa	Colour pattern on testa	Cotyledone colour
Binamasur-1	Rudimen-tary	White	Absent	Black	Marbled	Black	Orange/red
Binamasur-2	Rudimen-tary	White	Absent	Grey	Dotted	Grey	Orange/red
Binamasur-3	Promonent	White	Absent	Grey	Dotted	Grey	Orange/red
Binamasur-4	Rudimen-tary	White	Absent	Grey	Dotted	Grey	Orange/red
Binamasur-5	Rudimen-tary	White	Absent	Grey	Dotted	Grey	Orange/red
Binamasur-6	Rudimen-tary	White	Absent	Grey	Dotted	Grey	Orange/red

Table 36. Cont'd

Varieties	Pod shedding	Pod dehiscence	No. of pods/plant	No. of seeds/pod	No. of seeds/plant	100 seed weight (g)	Yield/palnt (g)
Binamasur-1	None	None	139	1.57	263	1.55	6.8
Binamasur-2	None	None	145	1.55	301	1.60	7.1
Binamasur-3	None	None	142	1.58	283	2.11	6.7
Binamasur-4	None	None	152	1.37	215	2.13	6.8
Binamasur-5	None	None	145	1.42	221	2.30	7.3
Binamasur-6	None	None	144	1.54	223	2.00	7.5



Flower



Plant



Pod bearing branch



Root



Pod



Seed

Binamasur-1

Fig. 55. Photograph showing different parts of lentil varieties



Flower



Leaf



Pod bearing branch



Plant



Pod



Seed

Binamasur-2



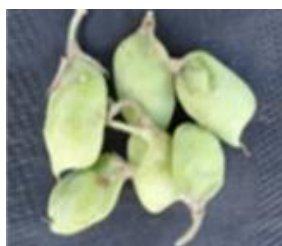
Flower



Plant



Pod bearing branch



Pod



Seed

Binamasur-3

Fig. 56. Cont'd



Flower



Leaf



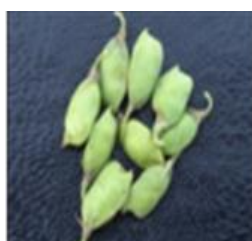
Plant



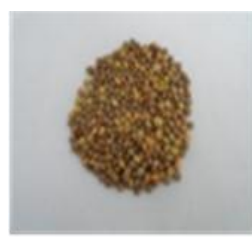
Pod bearing branch



Root



Pod



Seed

Binamasur-4



Flower



Leaf



Plant



Pod bearing branch



Pod



Seed

Binamasur-5

Fig. 55. Cont'd



Binamasur-6

Fig. 55. Cont'd

Table 37. Distinctness of the morphological characters of lentil germplasm

Germplasm	Seedling stem pigmentation	Leaflet size	Plant height (cm)	Days to flowering	Days of maturity	No. of primary branches/plant	No. of secondary branches/plant
LM-123-7	Absent	Small	27.10	54.40	107	4.20	12.80
LM-132-7	Absent	Small	31.60	51.80	106	3.80	10.80
LM-28-2	Absent	Small	23.60	56.00	106	3.80	8.00
LM-14-2	Absent	Small	28.20	51.40	106	3.80	7.80
LM-21-6	Absent	Small	25.00	53.20	107	3.60	11.40
LM-24-3	Absent	Small	26.20	43.80	102	4.60	9.80
LM-37-8	Present (slightly red)	Small	34.70	51.80	102	3.20	9.40
LM-48-1	Absent	Medium	29.40	57.20	105	4.40	10.20
LM-99-4	Absent	Small	26.80	56.00	105	4.20	11.40
LM-95-3	Absent	Small	24.40	61.60	103	3.20	9.00
LM-13-1	Absent	Small	27.60	57.80	104	5.60	13.80
LM-156-1	Absent	Small	27.80	60.20	108	5.40	12.80
LM-185-2	Absent	Small	26.60	62.40	110	5.00	11.60
LM-20-3	Absent	Small	29.60	55.80	108	5.40	11.80
LM-67-5	Absent	Small	31.20	58.40	110	5.80	11.80
LM-75-4	Absent	Small	27.40	60.80	109	4.20	9.00

Table 37. Cont'd

Germplasm	Seedling stem pigmentation	Leaflet size	Plant height (cm)	Days to flowering	Days of maturity	No. of primary branches/plant	No. of secondary branches/plant
ICARDA 2348	Present (reddish)	Medium	32.80	66.20	109	5.00	11.60
ICARDA 38211	Absent	Medium	34.00	67.40	110	5.60	14.40
ICARDA 23136	Present (slightly reddish)	Medium	29.40	67.20	107	8.20	16.80
ICARDA 23121	Present (slightly reddish)	Medium	30.20	65.80	108	5.40	14.80
ICARDA 23105	Present (reddish)	Medium	34.60	58.20	110	5.00	13.60
ICARDA 23128	Present (reddish)	Medium	36.60	71.20	108	6.00	19.80

Table 37 Cont'd

Germplasm	Tendrill length	Flower ground colour	Pod pigmentation	Height of the lowest pod (cm)	Ground colour of testa	Pattern of testa	Colour pattern on testa	Cotyledone colour
LM-123-7	Rudimentary	White with violet veins	Absent	5.80	Brown	Dotted	Black	Orange/red
LM-132-7	Prominent	do	Absent	6.68	Grey	Marbled	Black	Orange/red
LM-28-2	Prominent	do	Absent	5.80	Grey	Dotted	Black	Orange/red
LM-14-2	Prominent	do	Absent	5.60	Brown	Dotted	Black	Orange/red
LM-21-6	Prominent	do	Absent	6.20	Brown	Dotted	Black	Orange/red
LM-24-3	Prominent	do	Absent	6.00	Brown	Dotted	Black	Orange/red
LM-37-8	Prominent	White	Absent	7.60	Grey	Dotted	Black	Orange/red
LM-48-1	Prominent	White with violet veins	Absent	6.40	Grey	Dotted	Black	Orange/red
LM-99-4	Prominent	do	Absent	7.60	Grey	Dotted	Black	Orange/red
LM-95-3	Prominent	do	Absent	8.20	Grey	Dotted	Grey	Orange/red
LM-13-1	Prominent	do	Absent	6.20	Grey	Dotted	Grey	Orange/red
LM-156-1	Prominent	do	Absent	6.60	Grey	Dotted	Black	Orange/red
LM-185-2	Prominent	do	Absent	6.44	Grey	Dotted	Grey	Orange/red
LM-20-3	Prominent	do	Absent	6.80	Grey	Dotted	olive	Orange/red
LM-67-5	Prominent	do	Absent	6.30	Brown	Dotted	Grey	Orange/red

Table 37. Cont'd

Germplasm	Tendrill length	Flower ground colour	Pod pigmentation	Height of the lowest pod (cm)	Ground colour of testa	Pattern of testa	Colour pattern on testa	Cotyledone colour
LM-75-4	Prominent	do	Absent	6.20	Brown	Dotted	Grey	Orange/red
ICARDA 2348	Prominent	do	Absent	9.10	Grey	Dotted	Grey	Orange/red
ICARDA 38211	Prominent	Violet	Absent	14.20	Grey	Dotted	olive	Orange/red
ICARDA 23136	Prominent	White	Absent	9.40	Grey	Dotted	olive	Orange/red
ICARDA 23121	Prominent	White	Absent	9.40	Grey	Dotted	olive	Orange/red
ICARDA 23105	Prominent	White	Absent	13.20	Grey	Dotted	olive	Orange/red
ICARDA 23128	Prominent	White	Absent	8.80	Grey	Dotted	olive	Orange/red

Table 37. Cont'd

Germplasm	Pod shedding	Pod dehiscence	No. of pods/plant	No. of seeds/pod	No. of seeds/plant	100 seed weight (g)	Yield/palnt (g)
LM-123-7	None	None	201	1.57	308	2.63	7.99
LM-132-7	None	High	179	1.55	301	2.46	7.68
LM-28-2	None	None	121	1.58	188	2.09	4.03
LM-14-2	None	Low	152	1.37	211	2.55	5.52
LM-21-6	None	Low	154	1.42	221	2.37	5.39
LM-24-3	None	Low	155	1.54	239	2.85	6.90
LM-37-8	None	Low	122	1.61	199	1.54	3.16
LM-48-1	None	Low	124	1.58	193	2.27	4.03
LM-99-4	Low	Low	154	1.54	249	2.44	6.11
LM-95-3	Low	Low	149	1.41	190	2.41	4.65
LM-13-1	Low	Low	192	1.68	322	2.24	7.27
LM-156-1	Low	Low	175	1.51	261	1.78	4.88
LM-185-2	Low	Low	158	1.49	247	2.17	5.56
LM-20-3	None	Low	142	1.35	204	1.79	3.50
LM-67-5	Low	Low	166	1.31	221	2.30	5.18
LM-75-4	Low	Low	116	1.55	194	2.01	4.28
ICARDA 2348	None	Low	288	1.46	418	1.85	7.65
ICARDA 38211	Low	Medium	126	1.36	170	2.23	3.84
ICARDA 23136	Low	Low	120	1.21	149	1.68	2.52

Table 37. Cont'd

Germplasm	Pod shedding	Pod dehiscence	No. of pods/ plant	No. of seeds/ pod	No. of seeds/ plant	100 seed weight (g)	Yield/ palnt (g)
ICARDA 23121	Low	Low	105	1.63	173	2.01	3.24
ICARDA 23105	Low	Medium	119	1.58	181	2.17	4.00
ICARDA 23128	Low	Low	241	1.55	384	1.68	6.13



Leaf



Pod bearing branch



Flower



Pod



Seed

LM 67-5(15)

Fig. 56. Photograph showing different parts of lentil germplasm



Leaf



Pod bearing branch



Plant



Flower



Pod



Seed

LM-156-1(12)



Leaf



Pod bearing branch



Plant



Flower



Pod



Seed

IACRDA-23105(21)

Fig. 56. Cont'd



Pod bearing branch



Plant



Flower



Pod



Seed

LM-28-2(3)



Pod bearing branch



Plant



Flower



Pod



Seed

LM-21-6(5)

Fig. 56. Cont'd



Plant



Pod bearing branch



Flower



Pod



Seed

LM-99-4(9)



Plant



Pod bearing branch



Flower



Pod



Seed

ICARDA-38211(18)

Fig. 56. Cont'd



Plant

Pod bearing branch

Flower



Pod



Seed

ICARDA-2348(17)



Plant

Pod bearing branch

Flower



Pod



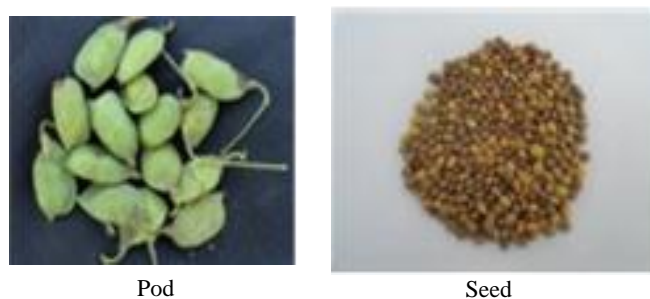
Seed

LM-123-7(1)

Fig. 56. Cont'd



LM-13-1(11)



LM-14-2(4)

Fig. 56. Cont'd



Plant



Pod bearing branch



Flower



Pod



Seed

LM-185-2(13)



Plant



Pod bearing branch



Flower



Pod



Seed

LM-48-1(8)

Fig. 56. Cont'd



Plant



Pod bearing branch



Flower



Pod



Seed

LM-75-4(16)



Plant



Pod bearing branch



Flower



Pod



Seed

LM-95-3(10)

Fig. 56. Cont'd



Plant



Pod bearing branch



Flower



Pod



Seed

ICARDA-23121(20)



Plant



Pod bearing branch



Flower



Pod



Seed

LM-132-7(2)

Fig. 56. Cont'd



Plant

Pod bearing branch

Flower



Pod



Seed

LM-37-8(7)



Plant

Pod bearing branch

Flower



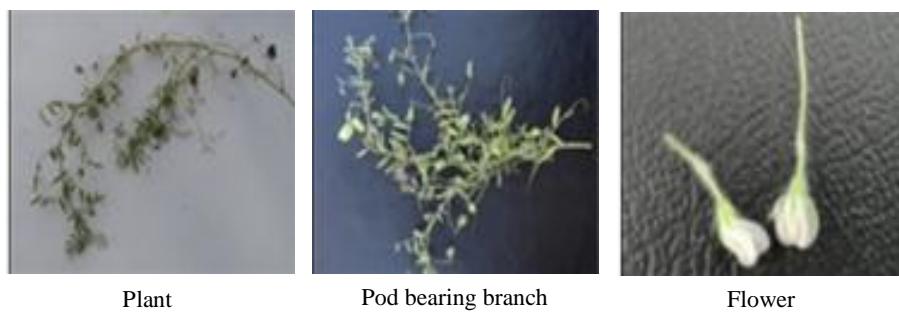
Pod



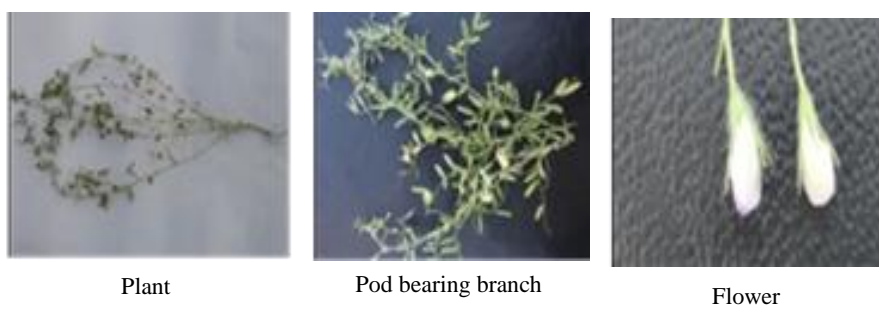
Seed

LM-20-3(14)

Fig. 56. Cont'd



ICARDA-2312(22)



ICARDA-23136(19)

Fig. 56. Cont'd

Molecular characterization of lentil germplasm using RAPD markers

Primer selection and RAPD pattern

Ten primers were initially screened on twenty two lentil germplasm for their ability to produce polymorphic patterns and 3 primers (OPC05, OPB08, OPB10) which gave reproducible and distinct polymorphic amplified products were selected. DNA amplification from all the primers tested in this study was not consistently reproducible, is a very common feature of RAPD technique. The present findings agree with those of Hadrys *et al.* (1992), and Williams *et al.* (1993). Technical problems from amplification of the RAPD technique in the field of genetic population research have also been reported by many authors (Schierwater and Ender, 1993; Lynch and Milligan, 1994).

A total of 24 RAPD bands were scored of which 12 (50%) polymorphic amplification products were obtained by using these arbitrary primers. The size of the amplification products ranged from 100-1000 bp (Table 38). The selected 3 primers produced comparatively maximum number of high intensity band with minimal smearing, good technical resolution and sufficient variation among different genotypes. The dissimilar numbers of bands were generated by primer OPC05, OPB08 and OPB10. Besides, the primer OPC05 amplified maximum number of polymorphic bands (87.50%) while the primer OPB08 generated the least (25.00%) polymorphic bands which were minimal in number. The banding patterns of 22 lentil genotypes using primers OPC05, OPB08 and OPB10 are shown in Fig. 57-59.

Table 38. RAPD primers with corresponding bands score and their size range together with polymorphic bands observed in 22 lentil germplasm

Primer code	Sequences (5'-3')	Total number of bands scored	Size ranges (bp)	Number of polymorphic bands	Proportion of polymorphic loci (%)
OPB08	GTCCACACGG	8	150-1000	2	25.00
OPB10	CTGCTGGGAC	8	150-1000	3	37.50
OPC05	AGGGGTCTTG	8	100-850	7	87.50
Total		24		12	150.00
Average		8		4	50.00

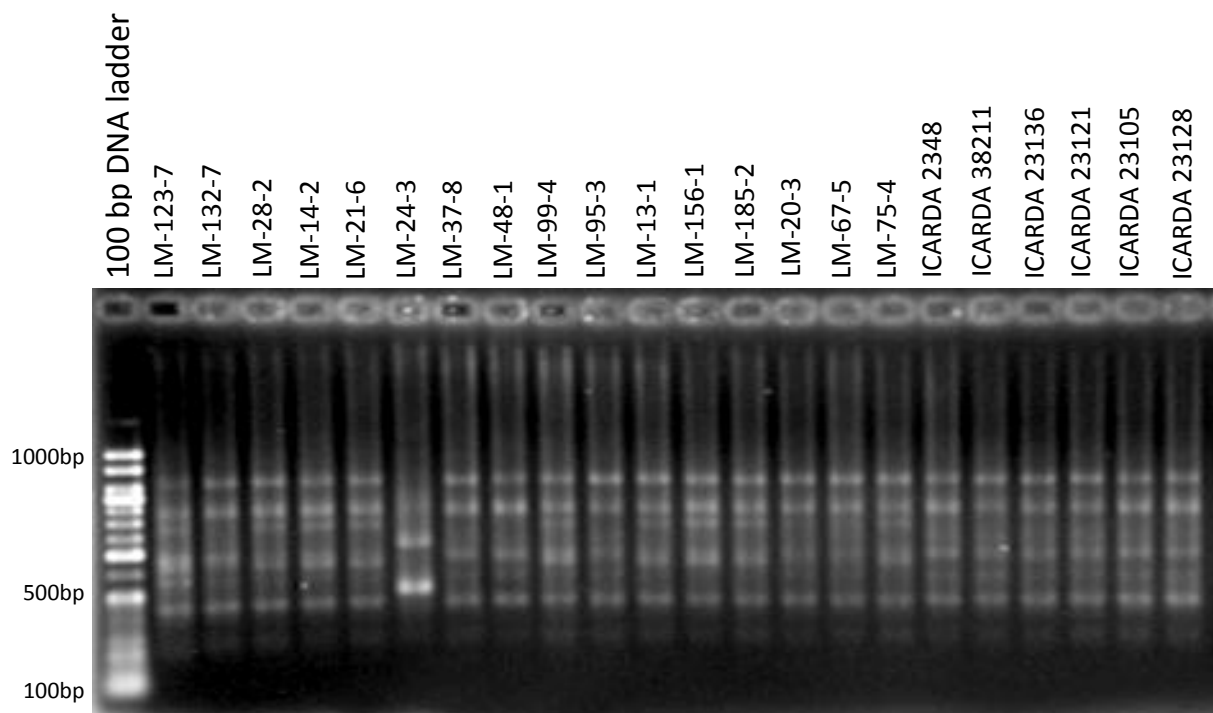


Fig. 57. RAPD profiles of different 22 lentil germplasm using primer OPC05

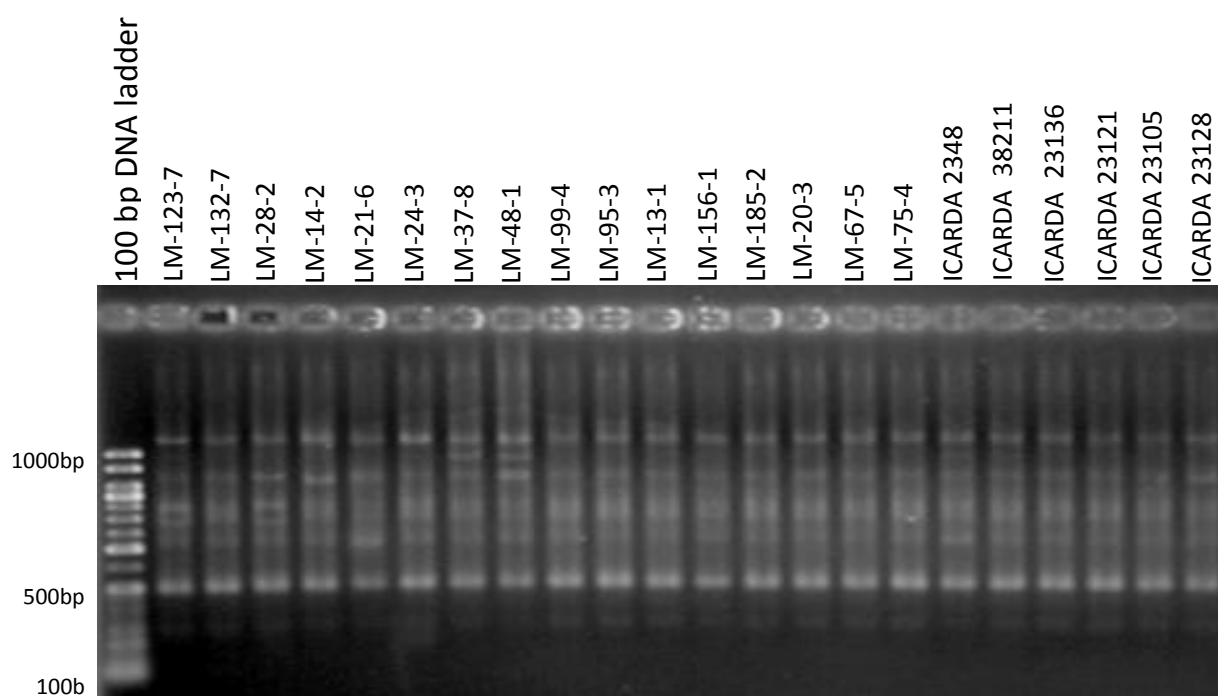


Fig. 58. RAPD profiles of different 22 lentil germplasm using primer OPB-08

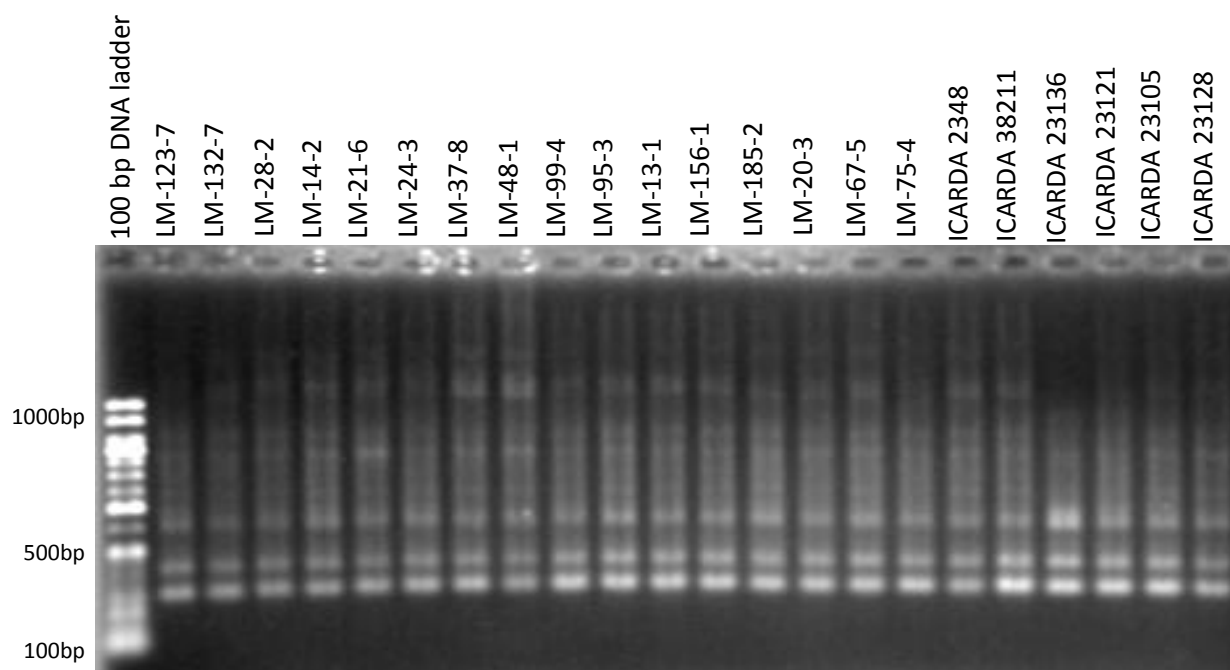


Fig. 59. RAPD profiles of different 22 lentil germplasm using primer OPB-10

Genetic variation

The estimate of Nei's (1973) genetic diversity for entire genotypes of lentil was 0.12 and Shannon's information index was 0.19. There was a high level of genetic variation among the studied genotypes of lentil from the proportion of polymorphic loci point of view.

Genetic distance and genetic identity

Pair-wise comparisons of Neil's (1972) genetic distance (GD) between lentil genotypes were computed from combined data for the three primers and the values ranged from 0.0000 to 0.4700. Comparatively higher genetic distance was observed between LM-24-3 vs. LM-28-2 and LM-75-4 vs. LM-24-3, while the lowest genetic distance 0.0000 was observed between the genotypes LM-185-2 vs. LM-14-2, LM-185-2 vs. LM-21-6 and ICARDA-23128 vs. ICARDA-23128. Considering the genetic distance values the result indicated that some genotypes of lentil are genetically different from each other and some are tend to be similar.

UPGMA Dendrogram

A dendrogram was constructed based on Nei's (1972) genetic distance following the Unweighted Pair Group Method of Arithmetic Means (UPGMA). The 22 genotypes of lentil were grouped into 2 main clusters namely cluster A and cluster B. (Fig. 60).

Genotypic variations based on molecular characterization indicated that genotypes belonging to different clusters depend on their genetic components itself, but not at geographical origin at all. Therefore, it could be concluded that for further research program, especially for hybridization, genotype could be selected from different clusters will be provided maximum heterosis regarding yield.

Rana *et al.* (2007) observed UPGMA cluster analysis for the combined data of RAPD and STMS revealed two broad clusters- Cluster I with three landraces and Cluster II containing all remaining landraces and cultivars except Precoz. Precoz was found to be the most distinct in individuals as well as combined analysis.

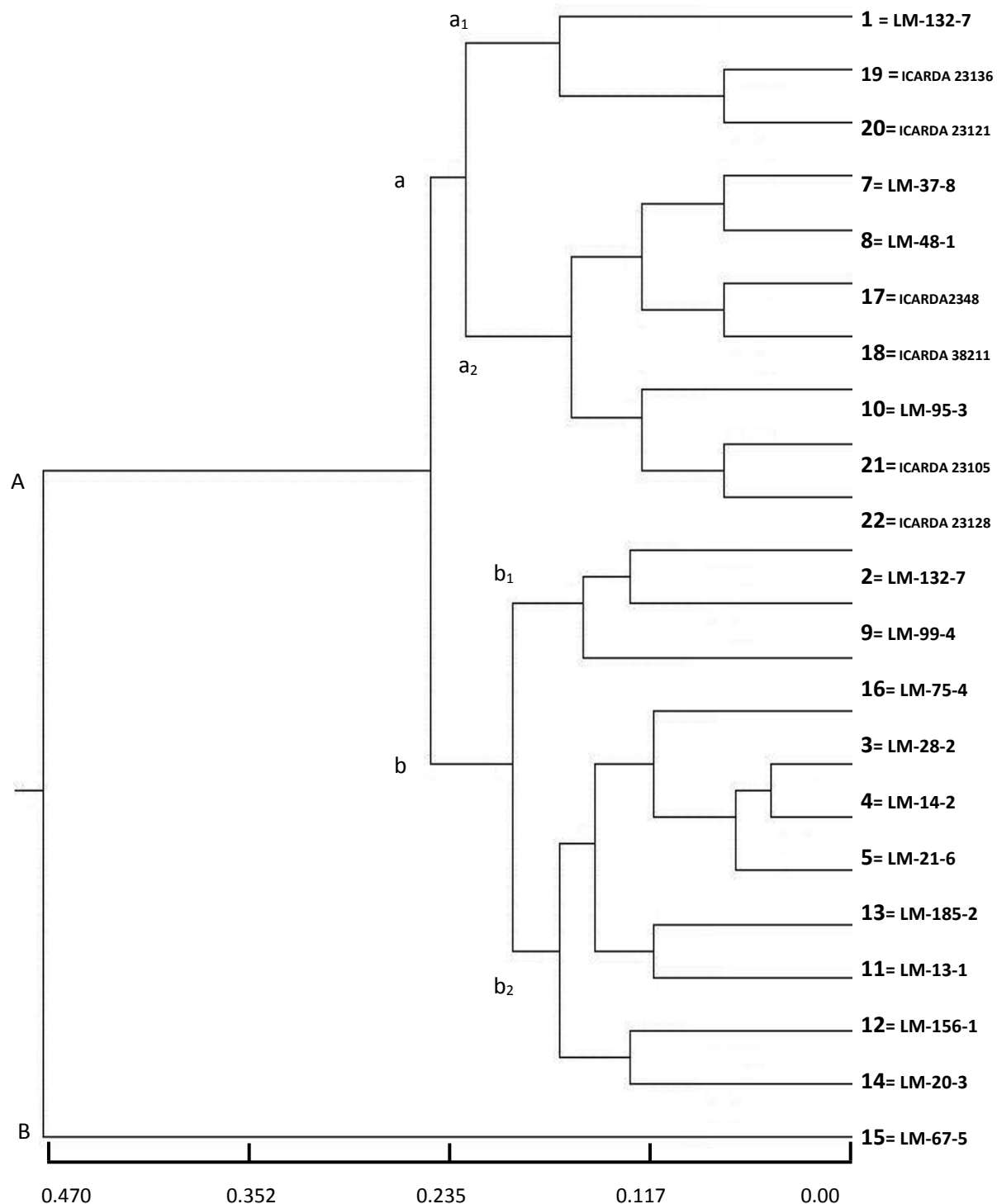


Fig. 60. Unweighted pair group method of arithmetic mean (UPGMA) dendrogram based on Neis's (1972) genetic distance, summarizing data on differentiation in 22 lentil germplasm according to RAPD analysis

Crop: Grasspea (*Lathyrus sativus*)**Morphological Characterization of Grasspea variety**

An experiment was carried out with one grasspea variety at BINA HQ farm Mymensingh during Kharif-1 season of 2012. Seeds were sown in RCB design with three replications. Unit plot size was 3m × 2m. Row to row and plant to plant distances were 40 cm and 10 cm, respectively. Recommended fertilizer doses were applied. Morphological characterization and identification of the traits of documentation for distinctness of the varieties/germplasm were recorded and photograph taken from the field using the approved descriptors of IBPGR and IPGRI. All the data are presented in Table 39 and Fig. 61. Rice varieties and germplasm are distinctly different with respect to grain colour, grain size-shape, length-breadth etc. Mutant variety Binakhesari-1 exhibits grey with dense black spotted seed coat.

Table 39. Distinctness of the morphological characters of grasspea variety

Sl. No.	State of the characters and codes	Binakhesari-1
1.	Eplcotyl colour	Light green
2.	Hypocotyl colour	Green
3.	Seedling vigour	Intermediate
4.	Plant growth rate-stage I	High
5.	Plant growth rate-stage II	Medium
6.	Plant growth habit	Spreading
7.	Plant type	Determinate
8.	Plant height (cm)	140
9.	Nodes per plant	Medium
10.	Internode length	Medium
11.	Stem colour	Green
12.	Stem wing width	Narrow
13.	Stem Waxy coating	Small
14.	Branch characters	Evenly distributed throughout the whole plant
15.	Anthocyanin pigmentation on leaf	Absent
16.	Leaf colour	Dark green
17.	Leaf size	Medium
18.	Leaf pubescence	Absent
19.	Days to 50% flowering	60-65
20.	Days to first mature pod	90-95

Table 39. Cont'd

Sl. No.	State of the characters and codes	Binakhesari-1
21.	Days to maturity	115-125
22.	Flower colour	Blue
23.	Calyx colour	Green
24.	Number of pods per plant	90-115
25.	Immature pod colour	Green with purple spot
26.	Mature pod colour	Brown
27.	Pod pubescence	Absent
28.	Number of seeds per pod	3-5
29.	Seed size	Medium
30.	Seed coat colour	Grey with dense black spotted
31.	Seed coat surface	Smooth
32.	100-seed weight (g)	4.56
33.	BOAA (%)	0.23



Seedling



Plant



Pod bearing branch



Pod



Seed

Binakhesari-1

Fig. 61. Photograph showing different parts of Binakhesari-1

Molecular Characterization of Binakhesari-1

Binakhesari-1 was characterized using RAPD markers. The ten primers initially tested among them, six primers (CS-27, OPF-20, OPF-05, OPF-18, 69AB10C9 and OPF-15) produced amplification products with high intensity, minimal smearing and good resolutions with clear bands. Banding pattern of RAPD markers is shown in Fig. 62.

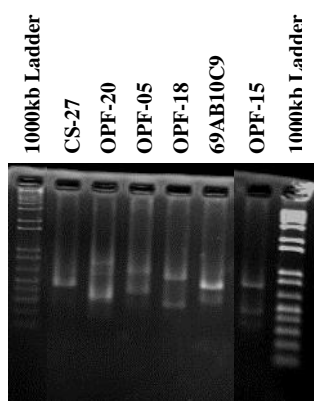


Fig. 62. DNA fingerprinting of Binakhesari-1, using RAPD markers (CS-27, OPF-20, OPF-05, OPF-18, 69AB10C9 and OPF-15)

Crop: Blackgram (*Vigna mungo*)

Morphological Characterization of Blackgram variety

An experiment was conducted with blackgram variety **Binamash-1** at BINA Head Quarter farm during Rabi season, 2012. Unit plot size was 5m x 0.8 m. Row to row and plant to plant distances were 40 and 15 cm, respectively. Morphological characterization and identification of the traits of documentation for distinctness of the varieties/germplasm were recorded and photograph from the field using the approved descriptors of IBPGR and IPGRI and are presented in Table 40 and Fig. 63.

Table 40. Distinctness of the morphological characters of blackgram variety

Sl. No.	State of the characters	Binamash-1
1.	Growth habit	Semi-erect
2.	Growth pattern	Determinate
3.	Leave	Acute
4.	Terminal leaflet length	Medium
5.	Leaf pubescence	Pubescent
6.	Leaf colour	Green
7.	Petiole colour	Green
8.	Petiole length	Short

Table 40. Cont'd

Sl. No.	State of the characters	Binamash-1
9.	Leaf senescence	Not visibly senescence
10.	Raceme position	No pods visible above canopy
11.	Calyx colour	Green
12.	Corolla colour	Deep yellow
13.	Pod colour at immature stage	Green
14.	Pod colour at mature stage	Black
15.	Shape of ripe pod	Round
16.	Pod length (cm)	4.5-5.0
17.	Pod pubescence	Present
18.	Constriction of pod between seed	Present
19.	Pod curvature	Least curve
20.	Seeds	Black
21.	Mottling of seeds	Absent
22.	Seed shape	Drum shaped
23.	Number of pods	30-50
24.	Plant height (cm)	20.0-25.0
25.	Yield/plant (g)	5.3



Leaf (ventral side)



Leaf (dorsal side)



Fruit bearing habit



Flower



Pod



Seed

Fig. 63. Photograph showing different parts of Binamash-1



Fig. 64. Monitoring Team of BARC visiting mustard field at BINA Head Quarter Farm, Mymensingh, rabi season, 2012-13

11. Research Highlights:

1. Characterization of crop varieties/ germplasm (68 rice, 17 mustard, 8 sesame, 14 soybean, 14 groundnut, 34 mungbean, 16 chickpea, 1 blackgram, 1 grasspea, 21 tomato, 8 jute, and 28 lentil genotypes) have been done morphologically.
2. Characterization of selected GI crops (1 Blackgram: Kalikolai, 1 Sesame: Local til and 1 Mungbean : Sonamug) have been done morphologically.
3. DNA fingerprinting of 58 rice, 10 mustard, 7 sesame, 7 chickpea, 6 soybean, 5 jute, 12 tomato, 1 grasspea, 5 mungbean, 4 groundnut and 22 lentil varieties/germplasm have been done using SSR/RAPD markers.
4. DNA fingerprinting of selected GI crops (1 Blackgram: Kalikolai, 1 Sesame: Local til and 1 Mungbean : Sonamug) have been done using SSR/RAPD markers.
5. i) Morphological organs of 68 rice, 17 mustard, 8 sesame, 14 soybean, 14 groundnut, 34 mungbean, 16 chickpea, 1 blackgram, 1 grasspea, 21 tomato, 8 jute, and 28 lentil varieties/germplasm and selected GI crops (1 Blackgram: Kalikolai, 1 Sesame: Local til and 1 Mungbean : Sonamug) were documented.
 ii) DNA fingerprinting of 58 rice, 10 mustard, 7 sesame, 7 chickpea, 6 soybean, 5 jute, 12 tomato, 1 grasspea, 5 mungbean, 4 groundnut and 22 lentil varieties/germplasm and selected GI crops (1 Blackgram: Kalikolai, 1 Sesame: Local til and 1 Mungbean : Sonamug) were documented.

12. Environmental Screening Matrix

Sl. No.	Environmental issue	Component	Baseline	Degree of Impact*								Remarks
				Small		Moderate		Large		None		
1	Biodiversity			Before	After	Before	After	Before	After	Before	After	
		Flora		+	+							
		Fauna								None	None	
		Genetic diversity				+	+					
		Exotic varieties		+	+							
		Local varieties/cultivars				+	+					
		Hybrids								None	None	
2	Soil quality	Organic matter								None	None	
		Chemical fertilizer use								None	None	
		Soil salinity								None	None	
		Fertility status								None	None	
		Microbial activity								None	None	
		Heavy metal contamination								None	None	
		Water quality								None	None	
3	Agro-Chemicals	Pesticide use								None	None	
		POPs								None	None	
		IPM								None	None	
		Pest infestation								None	None	
		Bio-pesticides								None	None	
		Health hazard								None	None	
4	Pollution	Soil								None	None	
		Water								None	None	
		Air								None	None	

13. Major Attainments (*in relation to the set objectives*) :

a. Technical : Output, Outcome and Impact

Sl. No	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)	Impact (long term effect of the research)	Remarks (reason, if anything otherwise plus any other)
1.	Morphological characterization of different crop varieties and germplasm	Characterization of crop varieties/germplasm (68 rice, 17 mustard, 8 sesame, 14 soybean, 14 groundnut, 34 mungbean, 16 chickpea, 1 blackgram, 1 grasspea, 21 tomato, 8 jute and 28 lentil genotypes) have been done morphologically	Skillness of the researchers/technicians has been developed	i) The characters identified as morphological and molecular would be useful in future breeding programme by the Plant Breeder ii) The printed documents of the characterization of different varieties/germplasm/ GI crops would be useful to researchers, academicians and policy makers.	
2.	Morphological characterization of different GI crops	Characterization of selected GI crops (1 Black gram: Kali kolai, 1 Sesame: Local til and 1 Mungbean : Sonamoog) have been done morphologically			
3.	Molecular characterization of different crop varieties and germplasm	DNA fingerprinting of 58 rice, 10 mustard, 7 sesame, 7 chickpea, 6 soybean, 5 jute, 12 tomato, 1 grasspea, 5 mungbean, 4 groundnut and 22 lentil varieties/germplasm have been done using SSR/RAPD markers			

Sl. No	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)	Impact (long term effect of the research)	Remarks (reason, if anything otherwise plus any other)
4.	Documentation of characterized crop varieties/germplasm morphologically and genetically	<p>-Morphological organs of 68 rice, 17 mustard, 8 sesame, 14 soybean, 14 groundnut, 34 mungbean, 16 chickpea, 1 blackgram, 1 grasspea, 21 tomato, 8 jute, and 28 lentil varieties/germplasm and selected GI crops (1 Blackgram: Kalikolai, 1 Sesame: Local til and 1 Mungbean : Sonamug) were documented</p> <p>- DNA fingerprinting of 58 rice, 10 mustard, 7 sesame, 7 chickpea, 6 soybean, 5 jute, 12 tomato, 1 grasspea, 5 mungbean, 4 groundnut and 22 lentil varieties/germplasm and selected GI crops (1 Blackgram: Kalikolai, 1 Sesame: Local til and 1 Mungbean : Sonamug) were documented</p>			

b. Procurement

Sl. No	Approved provisions of Procurement (list major items)	Achievement	% of achievement	Remarks (reason, if anything otherwise)
1.	Ice box (2)	Procured	100	
2.	Liquid nitrogen container	Procured	100	
3.	Computer with color laser printer	Procured	100	
4.	Digital Camera	Procured	100	
5.	Computer table	Procured	100	
6.	Chemicals and consumables (2011-2012)	Procured	100	
7.	Chemicals and consumables (2012-2013)	Procured	100	

N.B. All procured items are located in Biotechnology Division, listed in Store Book in Store Section and are being used by the scientists of this institute.

c. HRD/ Training: Not included in the Project

Title (e.g.Ph.D/MS/ Trainings, workshops conducted etc.)	Target	Attainments	No. of participants	Benefit of the higher studies/trainings(application of the learning, productivity enhancement)	Remarks (reason, if anything otherwise)

d. Financial:

Sl. No	Major Head	Fund received (Tk.)	Expenditure (Tk.)	Balance/Unspent (Tk)	Remarks (reason, if anything otherwise)
1.	Contractual Staff Salary	165000	165000		
2.	Field Research/ Lab expenses and supplies	1070351	1070351		
3.	Operating Expenses	117825	117825		
4.	Fuel, Oil and Maintenance	76350	76350		
5.	Training/Workshop/Seminar				
6.	Publications and printing	110000	110000		
7.	Contingencies	80975	80975		
8.	Capital Expenses	271199	271199		
9.	Total	1891700	1891700	00	

e. Materials developed/Publications made :

Type of material/publication	Title	Number	Remarks(being used by/meant for/any other)
Technology development			
Process development			
Information development	Morpho-molecular characterization of different crop varieties and germplasm	1(Annual Report-2012-13)	
Journal publication			
Books/Monographs/Manual published			
Booklet/leaflet/flyer etc. published			
Any other (patenting of technology etc.)			

14. Sub-project Auditing (cover all types of audit performed)

Types of Audit	Major observations/issues/objections raised, if any	Status at the sub-project end	Remarks
J.U. Ahmed & Co for the FY 2011-2012	N/A	-	
Govt. Audit	N/A	-	-

15. Reporting

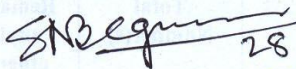
Report type	Actual date of submission(s)	Total Number(s)	Remarks
a. Inception report	06.01.2012	02.02.2012 26.5.2012	(Revised)
b. Monthly reports*	1 st week of every month	22 Nos.	
c. Statement of expdts.(SoE)*	1 st week of every month	22 Nos.	
d. Quarterly report(s)*	July, 2013	2Nos.	
e. Six monthly report	July, 2013	2Nos.	
f. Annual report	July, 2013	1 No.	
g. Procurement plan	06.01.2012	02.02.2012 26.05.2012	(Revised)
i. Environmental monitoring (Annual Basis)	06.01.2012	1 No.	
j. Social safeguard status (Before and at the end)	06.01.2012	1 No.	
k. Field Monitoring Report(s)**	09.06.2012 02.11.2012 01.12.2012 15.02.2013 03.03.2013 10.09.2013	6 No.	


16. Problem/Constraints:

- i. We could not attempt detail molecular analysis within project period which was important part of the project.
- ii. Adequate numbers of SSR/RAPD markers are required for molecular characterization.
- iii. Procurement of molecular reagents/chemicals under existing government rules is lengthy.

17. Suggestion for future, if any:

Duration of this project should be more than two years because we have taken 233 genotypes of 12 crops.

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Annexure 1 : List of Equipment

Procurement punched under this project (SPGR-375):

Sl. No	Name of the Equipment	Location of the Equipment
1.	Ice box (2)	All procured items are located in Biotechnology Division, listed in Store Book in Store Section and are being used by the scientists of this institute.
2.	Liquid nitrogen container	
3.	Computer with color laser printer	
4.	Digital Camera	
5.	Computer table	
6.	Chemicals and consumables (2011-2012)	
7.	Chemicals and consumables (2012-2013)	

Signature of the Principal Investigator

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